— 4/2/92

CITY OF SANTA CRUZ

WATER DEPARTMENT

WATER MASTER PLAN

FINAL REPORT

APRIL 1989

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April 12, 1989

Mr. William Kocher
Santa Cruz Water Department
City Hall, 809 Center Street
Santa Cruz, CA 95060

Subject: SCWD Water Master Plan -- Submittal of Final Report

Dear Mr. Kocher:

Leedshill-Herkenhoff (LH) hereby transmits the "Water Master Plan" prepared for the City of Santa Cruz Water Department (SCWD). This plan provides detailed projections of water demands through year 2005, evaluations of alternative improvements that are needed to meet the future demands, and a preliminary investigation of the adequacy of existing connection charges to cover the anticipated costs. Additionally, an analysis of alternatives for providing domestic service along the North Coast is included.

The primary conclusions developed during the course of our study are summarized in the Executive Summary at the front of the report. Comprehensive descriptions of the methodologies and results of our work are presented in subsequent chapters. In addition to this report, supplemental information is presented in two separately bound documents -- "Technical Appendices", which includes cost estimates and detailed explanation on the development of the Water Supply Operations Model, and "Guidelines for Optimal Use of Water Supply Sources", which presents the operating rules recommended for optimal utilization of the SCWD's unique collection of water supply sources.

LH has enjoyed the opportunity to conduct this important and challenging study for the City of Santa Cruz and wishes to acknowledge the invaluable assistance provided by the numerous SCWD staff members during the course of our work. Their cooperation and prompt responses contributed significantly to the thoroughness and accuracy of our studies.

If we can be of any further assistance, please do not hesitate to call. We look forward to providing continued assistance to the SCWD on the planning, design, and implementation of future water supply projects.

Respectfully submitted,

William J. Bardin
Project Manager

Robert O. Sverak
Project Engineer

CITY OF SANTA CRUZ

City Council

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City of Santa Cruz

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LEEDSHILL-HERKENHOFF, INC.

CITY OF SANTA CRUZ WATER DEPARTMENT

WATER MASTER PLAN

The following report and all related studies were conducted under the supervision of a registered Civil Engineer in the State of California.

REGISTERED PROFESSIONAL ENGINEER
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William J Bardin

WILLIAM J. BARDIN
Civil Engineer

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City of Santa Cruz Water Department
Water Master Plan

REPORT OUTLINE

CHAPTER 3 - WATER DISTRIBUTION SYSTEM

CHAPTER 4 - EXISTING WATER SUPPLY SYSTEM

CHAPTER 5 - WATER QUALITY AND TREATMENT

CHAPTER 6 - ALTERNATIVES FOR NORTH COAST DOMESTIC SERVICES

CHAPTER 7 - DESCRIPTION OF WATER SUPPLY ALTERNATIVES

CHAPTER 8 - EVALUATION OF WATER SUPPLY ALTERNATIVES

CHAPTER 9 - PROPOSED IMPROVEMENTS

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Note: Appendices D, E, and F are bound in a separate document, entitled "Technical Appendices."

City of Santa Cruz Water Department
Water Master Plan

EXECUTIVE SUMMARY

As authorized by a contract agreement dated September 8, 1987, the City of Santa Cruz Water Department (SCWD) retained Leedshill-Herkenhoff, Inc. to prepare a master plan for water supplies through the year 2005. The following report and separately technical bound appendices contain detailed information and explanation on the study's background, methodologies employed, results, conclusions, and recommendations.

This Executive Summary presents only the major assumptions and conclusions derived during the course of the water master plan study. The proposed improvement projects and recommended additional studies, including preliminary cost estimates, are summarized in Chapter 9. Following the list of key conclusions given below, the Executive Summary is divided into four sections:

(1) Water Demand Projections
(2) Water Distribution System
(3) Water Quality and Treatment
(4) Water Supply System

To summarize, the key conclusions developed in this study are:

- The total water supply requirements for the SCWD service area in year 2005 are projected to be about 4900 to 5200 million gallons per year (MG/YR), depending on growth at The University of California at Santa Cruz (UCSC), the status of existing greenbelt areas, and other uncertainties.

- With adoption of the proposed operating rules, availability of the full capacity of the Beltz well system and <u>required</u> improvements to the North Coast supply system, the supply capability of the SCWD's existing sources will be significantly enhanced. Operations studies indicated that optimal use of the existing sources should allow the SCWD to meet <u>current</u> demands in virtually all years, with only minor supply deficiencies in severe droughts such as 1976-77.

- SCWD's existing water supply sources, <u>with certain upgrades</u>, are capable of meeting year 2005 demands under the high growth scenario in about 90 to 95 percent of all years. Minor supply deficiencies requiring a mild, voluntary conservation effort would occur in roughly 8 percent of all years. Major supply deficiencies requiring strict conservation measures would occur only in rare, extremely severe droughts such as that experienced in 1976-77.

- Several potentially viable alternatives involving existing water supply sources (i.e., already developed by SCWD or others) would increase the dry year yield of the SCWD water supply system at a relatively low cost. Although supply deficiencies would still occur in the most severe droughts, minor supply deficiencies would be almost completely eliminated. Therefore, the overall frequency of supply deficiencies would be reduced to less than 5 percent of all years. Depending on the alternatives chosen, the total construction cost would be in the range of $3 to 5 million.

- Construction of a new surface water storage reservoir similar in size to Loch Lomond Reservoir would almost completely eliminate the possibility of any water supply shortages under the projected maximum demand for year 2005, even under extreme drought conditions such as 1976-77. However, such a project would be difficult to implement, would take at least 10 years to implement, and would cost at least $10-15 million.

WATER DEMAND PROJECTIONS

1. A thorough survey of projected changes in land use, population, and housing was conducted to estimate the potential increase in water supply requirements within the SCWD service area through year 2005. As directed by the City Council, the so-called "inner line" service area has been used as the basis for projections rather than the "ultimate" service area used in other studies. In recognition of uncertain conditions, both high and low growth scenarios were examined to represent the potential range of water supply requirements in year 2005. The high growth scenario is based on a 15,000 enrollment at UCSC and complete development of 341 acres of existing greenbelt areas. The low growth scenario is based on a 12,000 enrollment at UCSC in 2005 and an assumed irrigation demand for 10 percent of the existing greenbelt acreage (other 90 percent undeveloped).

2. Land use, housing, and population projections were then multiplied by appropriate unit water use factors to estimate the total water demand. An upward adjustment was then made to account for system losses and other unmetered uses to derive the total water supply requirements.

   Due to SCWD's incoming water conservation ordinance, technological improvements in plumbing fixtures, and recently implemented state laws, future development will use less water on a <u>unit</u> basis than existing development. In this study, the impacts of conservation measures were only included for indoor residential use in <u>future</u> construction. Future residential dwelling units will use approximately 19 percent less water than the current average residential dwelling unit. Other potential conservation impacts such as increased use of low water-using landscape materials were not included in the demand projections because of uncertainty on their true impact on future water demand.

3. Total water use among current residential customers is expected to remain relatively constant as increased conservation efforts will be offset by home additions and/or increased population densities. Total water use by other classifications is expected to decrease slightly but has not been adjusted in the water demand projections.

4. Total water supply requirements for the SCWD service area will increase to about 4900 - 5200 MG/YR by year 2005. The range in values represents the low and high growth scenarios. For comparison purposes, the current total water supply requirement is about 4200 MG/YR.

WATER DISTRIBUTION SYSTEM

1. The existing computer model of the SCWD water distribution system was updated to include recent additions. The model was then used to determine if the system could deliver water under projected future demands at adequate pressures at all times. The high growth demand scenario was used in the computer model.

   The computer analyses indicated three areas which would need upgrading to avoid unacceptably low delivery pressures. These areas include the northern portion of Live Oak (generally north of Capitola Avenue), the far western side of the service area, and the UCSC transmission system. These areas contain the vast majority of anticipated future growth and do not have adequate facilities in place to meet future demands.

2. The necessary pipeline improvements to the Live Oak and west side lands will cost approximately $1 million. These pipelines represent the primary distribution mains and, as such, do not include extensive local piping which will be needed to distribute water within and around new developments.

3. Anticipated growth at UCSC will require substantial improvements to the UCSC water system such as a new potable water reservoir and upgrades to existing pump stations. The total implementation cost of these improvements is expected to be about $1 million.

4. Depending on the water supply alternatives selected for implementation, other modifications or additions to the distribution system may be required.

WATER QUALITY AND TREATMENT

1. Due to new water quality standards, delivery of unfiltered water to domestic customers along the North Coast pipeline and/or Bay Street Reservoir will no longer be allowed. The recommended alternative for providing fully treated water to the North Coast domestic customers is to construct a 4-inch diameter pipeline extending 7 miles up the coast from Bay Street Reservoir. The total cost of this plan is approximately $750,000.

2. Existing treated water supplies are safely meeting all current water quality standards and are considered to have good overall water quality. The recent modifications to Graham Hill Water Treatment Plant have provided the flexibility and reliability to provide the necessary treatment for all the water sources for both existing as well as anticipated future regulations. However, more stringent standards anticipated in the near future may significantly increase the amount of testing, sampling, and reporting of water quality data and may require some modifications to existing treatment procedures and/or additional facilities to provide advanced treatment. The new regulations will most likely impact filter-to-waste, disinfection, trihalomethane, and lead/copper/pH standards. Additional treatment works to meet future standards may cost several million dollars and would dramatically increase the annual operation and maintenance expense at Graham Hill Water Treatment Plant.

3. The proposed operating rules and alternative supply improvements presented in this master plan report are not expected to have a significant impact on overall water quality. The operating rules discussed in Chapter 8 will likely decrease the use of Loch Lomond Reservoir relative to recent years but no significant adverse impacts on water quality and treatment are anticipated relative to current operations. Use of the high-quality North Coast water will still have the highest priority. Therefore, potential difficulties in meeting future water quality standards are likely to be more closely related to stringent requirements rather than the suggested operational changes. Adequate data to make a conclusive determination on this matter are not available at this time. Once the final regulations are promulgated, a testing program should be conducted to evaluate the use of the proposed operating rules relative to water quality.

   Once (if) a new reservoir site is selected for further study, water quality analyses for this new source will be carried out. Water quality from all proposed sources is expected to be similar to that of the SCWD's existing sources.

WATER SUPPLY SYSTEM

1. The SCWD's existing water supply system was closely examined in order to obtain a sound understanding which could then be utilized to suggest improvements for "optimizing" the operation of the system. All aspects of the operation of existing sources and their associated facilities were reviewed including sizes and capacities of facilities, water rights, unit production costs, and current operational procedures.

2. A detailed computer model was developed to simulate actual operation of the SCWD water supply system. The model "operates" the existing supply system at an assumed demand over the historical hydrologic conditions from 1921 to 1986, the period for which streamflow data are available. Based on selected operating rules for the existing sources and facilities, the operations model determines if adequate supplies would be available in each of the hydrologic years. If supply deficiencies occur during drought periods, the required extent of the demand reduction (i.e., conservation measures) is also determined by the model.

3. Based on analysis of historical hydrologic data, the Operations Model was used to determine the "optimal" operating rules for existing SCWD sources such as Loch Lomond Reservoir, Beltz Wells, and Felton Diversion. These operating rules, which essentially set priorities to determine when or if a source should be used, are designed to maximize dry year yield while maintaining a proper balance with water quality and operating costs.

4. Based on the rainfall and streamflow which occurred over the 66-year historical period from 1921 to 1986, the Operations Model (with the proposed operating rules) indicated that SCWD's <u>existing</u> water supply sources (with certain upgrades) can provide a firm or "safe" yield of about 4250 MG/YR, which is approximately equal to the total current demand. In other words, the SCWD's existing water supply sources could meet the demand of existing development in the future with almost zero probability of shortages, even under severe drought conditions such as those experienced in 1976-77. The analysis verified that the conditions experienced in the 1976-77 drought were <u>by far</u> the most critical drought period for the years 1921-86.

5. The severe water supply shortage and associated water rationing actually experienced by the SCWD in 1977 was mostly a result of operational problems at the Tait Street Diversion on the San Lorenzo River, <u>not hydrologic conditions</u>. This diversion, which normally supplies a substantial portion of the SCWD demand, produced only 1500 MG between April 1974 and October 1975. Analysis of the streamflow records for this period indicated that approximately 3300 MG could have been diverted. The large loss of production from the Tait Street Diversion required large withdrawals from Loch Lomond Reservoir during this

period. Therefore, the storage volume at Loch Lomond Reservoir in October of 1975 (immediately prior to the beginning of the drought) was extremely low -- just over 50 percent of total capacity.

In essence, the operational problems at the Tait Street Diversion occurred at the worst possible time, effectively extending the natural two-year drought of 1976-77 to an even more severe, artificial three-year drought. If the Tait Street Diversion would have operated at normal levels prior to the drought, water rationing would not have been needed. The operational problems experienced at that time are believed to be related to electrical malfunctions at the pump station which are no longer a concern since the pump station was relocated a few years ago. Turbidity constraints on the North Coast supply system and less than optimal operating rules, both of which will be corrected following implementation of this master plan, also contributed to the severe water shortage in 1977.

6. Based on the rainfall and streamflow which occurred over the 66-year historical period from 1921 to 1986, the Operations Model (with the proposed operating rules) indicated that SCWD's <u>existing</u> water supply sources (with certain upgrades) would be adequate to meet the projected <u>high growth</u> demand in year 2005 over 90 percent of all years. In the remaining 10 percent of years, the supply deficiencies would typically be minor, probably requiring only a public information program. Only severe droughts such as that experienced in 1976-77 would result in major supply deficiencies requiring mandatory rationing. In the Operations Model simulation, 1976 and 1977 were the only years in the 1921-86 study period during which major supply deficiencies would occur under the projected demand for year 2005.

   Therefore, the SCWD's collection of existing water supply sources is basically adequate to meet year 2005 demands except during rare, extremely severe droughts such as 1976-77. Periods of mild drought, even if persisting for 2-3 years, will not impact the system's ability to meet year 2005 demands.

7. Consecutive critically dry years such as 1976-77 are very rare and are only expected to occur roughly once every 50 to 100 years or so. Based on review of rainfall and streamflow records from 1897-1988, the 1976-77 drought was by far the worst 2-year drought period over the last 92 years. The 1987-88 drought conditions are the second or third worst 2-year drought period over the last 92 years. Conclusive rainfall data on the winter of 1988-89 was not available at the time this report was prepared.

8. Numerous alternatives for increasing or "optimizing" the dry year yield of the existing water supply sources were investigated. Because the existing water supply sources (with certain upgrades) are adequate to meet year 2005 demands in most years, emphasis was placed on developing

additional yield during critical dry periods. Additional yield in "normal" hydrologic years would increase the system's reliability but have no significant impact on the system's ability to produce dry year yield due to the limited amount of available storage.

9. Based on results from the Operations Model over the 66-year study period, it appears that several alternatives involving "existing" sources (i.e., sources already developed by SCWD or others) could significantly reduce supply deficiencies during an extreme drought period such as 1976-77. Examples include additional groundwater wells or a potential intertie program with Scotts Valley Water District. Although supply deficiencies would still exist in the second year of a severe two-year drought (e.g., 1977), these alternatives involving "optimal" use of existing sources could significantly reduce the required extent of rationing or other conservation measures and would also eliminate supply deficiencies in all but the most severe droughts. For example, the entire demand in year 2005 under the high-growth scenario could be met over 95 percent of all years. Furthermore, many of the alternatives considered would provide the additional firm yield in the critical dry year at a relatively low unit cost.

   While minimizing the frequency and magnitude of potential supply deficiencies, alternatives involving expansion or optimization of existing sources will not completely eliminate the need for some mandatory rationing during the most severe 2-year droughts. However, various combinations of these "existing source" alternatives would significantly decrease the frequency and magnitude of supply deficiencies, possibly to an acceptable level.

10. Construction of an additional surface water reservoir similar in size to Loch Lomond Reservoir would almost completely eliminate the possibility of supply deficiencies under year 2005 demands even under the most severe drought conditions such as those experienced in 1976-77. The additional storage would not necessarily be used under normal conditions since it would be needed only during the most severe drought periods. Because the role of a new reservoir would be limited to augmenting existing sources during infrequent severe drought periods, the reservoir does not have to be located on a major stream with high average streamflows. Furthermore, in almost all years, the total natural flow of the stream could be released or even augmented by the new reservoir. Until a major drought occurs, the reservoir could essentially remain full at all times, with no additional stream diversion after initial filling except to replace evaporation losses and drought use. Therefore, due to this proposed operation for a potential new reservoir, possible adverse environmental impacts, particularly impacts on fisheries, <u>may</u> be less critical relative to typical diversion and storage projects.

11. Two primary concepts have been studied for constructing an additional storage reservoir for the SCWD water supply system -- (1) a dam and reservoir on the North Coast which could be tied into the existing North Coast Pipeline and (2) a dam and reservoir in the upper San Lorenzo River basin which could release water for capture downstream at the SCWD's existing Felton and/or Tait Street Diversions on the San Lorenzo River.

    Tables ES-1 and ES-2 display the various water supply alternatives analyzed in this study, the results of the operations studies, and the equivalent annual cost for implementation.

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Table ES-1

City of Santa Cruz Water Department
Water Master Plan

WATER SUPPLY ALTERNATIVES

Alternative No.	Description
1	Upgrade Existing Supply System 1/
2A	Increase Capacity of Felton Diversion
2B	Reduce Operating Margin at Felton Diversion
3	North Coast Pump Stations
4	Parallel Pipeline from SLR to GHWTP
5A	Groundwater Wells and WTP near Thurber Lane (Purisima wells)
5B	Groundwater Well in Harvey West area
6	Wastewater Reclamation
7A	Enlarge Loch Lomond Reservoir by 260 MG
7B	Enlarge Loch Lomond Reservoir by 1010 MG
8A	Scotts Valley Intertie
8B	Soquel Creek Intertie
9	Direct Diversion on Zayante Creek
10	Parallel Coast Pipeline
11	North Coast Reservoir
12	Upper San Lorenzo River Reservoir

1/ Upgrade includes proposed operating rules, two additional pumps at Felton Booster Station, elimination of 1 NTU turbidity limit on North Coast sources, and additional maintenance of key production facilities, particularly during drought years.

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Table ES-2

City of Santa Cruz Water Department
Water Master Plan

SUMMARY OF ALTERNATIVES

SUPPLY ALTERNATIVE	FIRM YIELD (MG/YR)	OPERATIONAL YIELD ANALYSES: PERCENTAGE OF YEARS FOR 1960-1986 WITH: Full Supply	Voluntary 1/ Conservation	Mandatory 2/ Rationing	MAXIMUM ANNUAL DEFICIENCY (MG/YR)	EQUIVALENT ANNUAL COST 3/ ($)
1. Upgrade Existing System	4,240	89%	8%	3%	1,341	$27,000
2A. Increase FD to 14 CFS	4,275	92%	5%	3%	1,279	$174,000
2B. Reduce FD Op. Margin	4,255	89%	8%	3%	1,311	$8,000
3. Add Pumps at North Coast	4,245	89%	8%	3%	1,311	$21,000
5A+5B. Additional Wells	4,555	97%	2%	2%	1,057	$77,000
6. Wastewater Reclamation	4,325	91%	6%	3%	1,247	$50,000
7A. Raise Newell Creek Dam 4'	4,400	94%	3%	3%	1,247	$32,000
7B. Raise Newell Creek Dam 14'	4,770	97%	2%	2%	1,057	$160,000
8A. Construct Intertie to SVWD	4,750	97%	2%	2%	898	$205,000
11. North Coast Reservoir	5,170	98%	2%	0%	183	$1,236,000
12. San Lorenzo R. Reservoir	5,355	100%	0%	0%	0	$864,000
Combination 1+2B+5A+5B	4,570	97%	2%	2%	1,026	$112,000
Combination 1+2B+5A+5B+8A	5,075	98%	0%	2%	1,006	$317,000

1/ Requires public information program for reductions of up to 15 percent of the summer monthly demand.
2/ Mandatory rationing may be needed for reductions of more than 15 percent of the summer monthly demand.
3/ Present worth of total construction costs, additional O&M costs, and energy and treatment costs for implementing each alternative independently; the costs for Alternative 1 should be added to the costs shown for each alternative to give the true cost of implementing the alternative.

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

The latest water master plan for the City of Santa Cruz Water Department (SCWD) was prepared 25 years ago and relied primarily on impoundment of surface water for development of additional supplies to meet the increasing demand due to growth in the Santa Cruz area. However, the recent North Santa Cruz County Water Master Plan Study (COUNTY MP), a comprehensive water resources study commissioned by the joint efforts of nine local water agencies, concluded that future water supplies might be better provided by greater dependence on groundwater development and interconnection among existing water systems. The COUNTY MP concluded that the SCWD can meet long-term demands through development of additional groundwater resources.

Because the existing master plan was no longer useful for guiding SCWD's water supply planning, a new water master plan was desired in order to reflect current conditions and projected growth impacts, and to provide water supply planning guidelines which are environmentally, politically, and socially acceptable. The overall objective was to develop a comprehensive water master plan that will guide SCWD activities for the next 15 years in the following areas:

- Efficient use of existing sources and facilities to the fullest extent that is environmentally feasible;
- Cost-effective and environmentally sound development of any needed additional sources and facilities;
- Exploration of alternative means of eliminating deficiencies within the existing system; and
- Equitable allocation of costs of new facilities among SCWD customers.

1.2 AUTHORIZATION

The City of Santa Cruz Water Department (SCWD) engaged Leedshill-Herkenhoff, Inc. (L-H), in association with Metcalf and Eddy, Inc. (M&E) and John Gilchrist and Associates (JG&A), to prepare the Water Master Plan. The study was authorized by a written contract dated September 8, 1987.

1.3 SERVICE AND STUDY AREAS

The service area used in water demand projections in this water master plan consists of the existing SCWD service area shown in Figure 1-1. The boundaries of this service area encompass the area within which the SCWD can currently extend water service without special approval from the City Council. An alternative service area, often referred to as the "ultimate" service area, was used in the COUNTY MP and covers a much larger area. However, based on instructions from the City Council, the so-called "inner line" service area was used in this study.

As shown on Figure 1-1, the SCWD service area is nearly coincident with the existing city limits but includes unincorporated areas such as the Pasatiempo-Carbonera area just north of the city limits and the Live Oak area to the east of the city limits. The service area also includes the University of California at Santa Cruz (UCSC), a limited area within the Capitola city limits, and several domestic and agricultural connections along Highway 1 on the North Coast.

In addition to the primary service area, the study area included various hydrologic basins along the North Coast, the expansive San Lorenzo River watershed, and the Soquel Creek watershed. These areas were investigated for evaluation of current and alternative sources of water supply.

1.4 SCOPE OF WORK

The scope of work for this master plan study consisted of water demand projections, numerous hydrologic and hydraulic analyses, and economic analyses required to satisfy the objectives listed above. The tasks required to complete these analyses included the following:

- Determine accurate, reliable estimates of the future water requirements of the SCWD service area;
- Develop recommendations for the optimal use of the existing sources of supply and associated facilities;
- Identify and evaluate additional sources of supply;
- Analyze and evaluate the existing distribution system, including water treatment procedures and facilities;
- Develop a priority list of capital improvements; and
- Develop financing guidelines.

Service Area

CITY OF SANTA CRUZ WATER DEPARTMENT
Water Master Plan

Leedshill-Herkenhoff, Inc.
Metcalf & Eddy, Inc.
November 1988

Figure 1-2 shows a flow chart indicating the general sequencing of and interrelationships between the ten primary tasks. Data required to conduct the master plan study were obtained from SCWD records, discussions with SCWD staff and numerous individuals from local water and land use agencies, and a wide variety of reports from previous studies.

1.5 PREVIOUS STUDIES

Wherever possible, existing information was used to minimize duplication of work that was already satisfactorily completed. Numerous reports were reviewed and, if appropriate, used as a starting point for the analyses required in this master plan study. The studies outlined in the following subsections were of particular value to this study.

1.5.1 North Santa Cruz County Water Master Plan (COUNTY MP)

The COUNTY MP was a comprehensive water resources study conducted by a private consulting team under the authority of a joint powers agreement between nine water agencies in northern Santa Cruz County. The study was completed in 1985 and produced over 20 separate reports documenting the methodologies, findings, and conclusions developed in each aspect of the study.

The COUNTY MP provided information on the water supply outlook for each of the nine individual agencies based on detailed supply and demand projections. Water demand projections were based on a computer model developed from detailed land and water use data. Estimates of water supplies were made from gaged and synthesized records of monthly streamflow and rainfall. Alternative regional water supply plans were developed to meet the projected future demands.

Due to the obvious similarities, the data developed in the COUNTY MP were reviewed and utilized wherever possible during the course of this study to minimize duplication of effort and retain consistency between the studies. However, as described in other sections of this report, much of the available data were not of direct use.

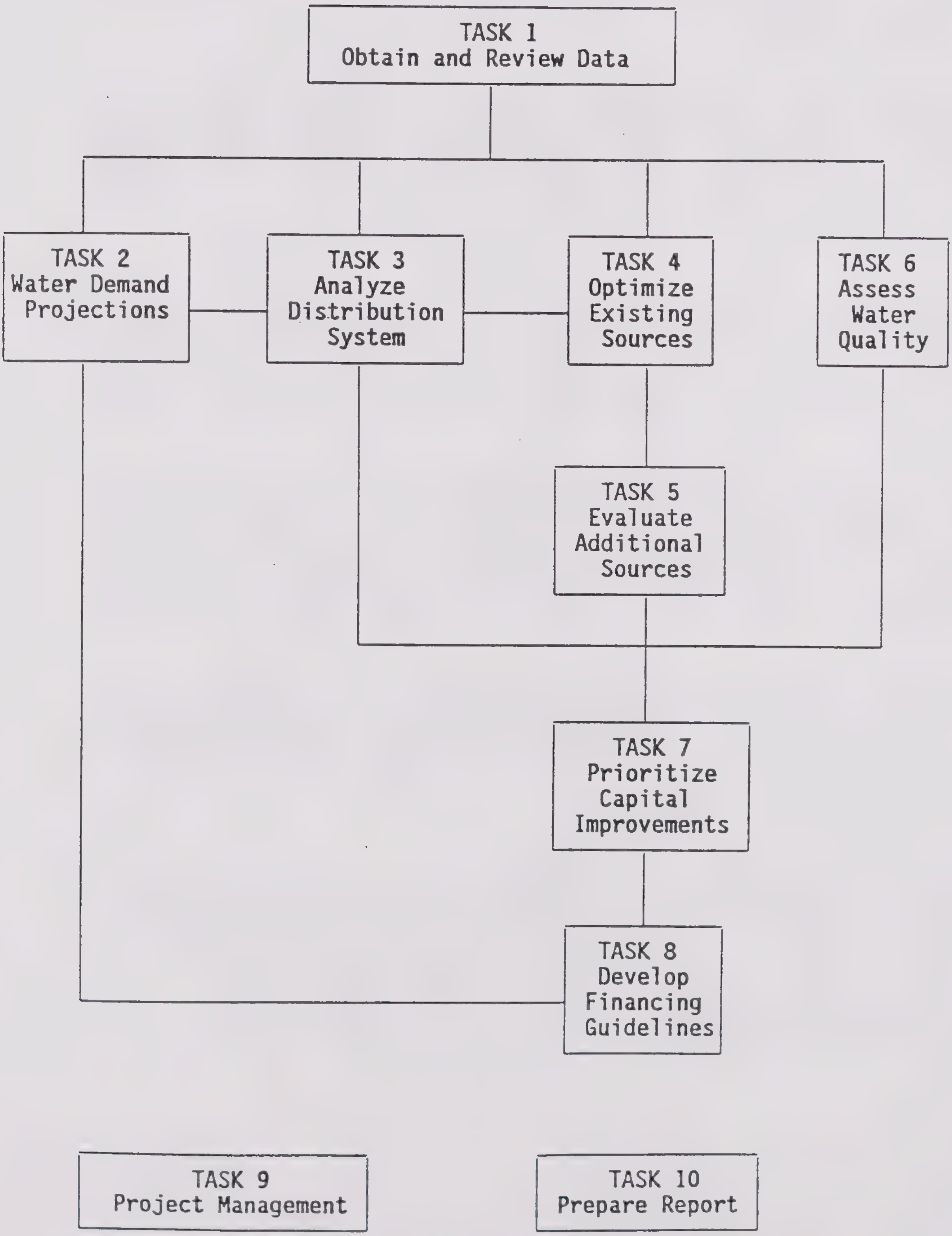
1.5.2 Groundwater Investigations

Additional groundwater sources in the Santa Cruz area have been previously explored during a number of different investigations. The following are past groundwater exploration projects relevant to this master plan study:

- Earth Sciences Associates (1979) - explored North Coast, Harvey West Park and industrial area, and downtown Santa Cruz-Nearys Lagoon area.

CITY OF SANTA CRUZ WATER DEPARTMENT
WATER MASTER PLAN

TASK INTERRELATIONSHIPS



- North Coast Exploration (1981) - drilled test wells at the north end of Jolly Spur on the North Coast and off Dimeo Lane.

- Ranney Method Western Corp. (1981) - constructed test wells along the east side of the San Lorenzo River.

- Brown and Caldwell (1983) - explored the Harvey West industrial area.

- Luhdorff & Scalmanini (1987) - tested south end of the Harvey West area, the Purisima formation (off Thurber Lane and near Beltz Wells), and two sites in the North Coast area.

A staff report prepared by SCWD in May of 1987 summarized the results of prior and ongoing investigations and concluded that additional groundwater development available to SCWD has limited potential and will probably not provide a major source of water supply.

1.5.3 Other Relevant Studies

Several other recent studies have produced information relevant to this water master plan study. Some of the more important studies are described in the following paragraphs. A more comprehensive list of relevant studies is included in the list of references shown in Appendix A.

In Linsley Kraeger Associates' (L-K) 1980 study on The Effect of Fishery Releases on the Yield of Zayante Reservoir, several important streamflow records were extended using correlations to other available data. The available 1961-1979 streamflow record for San Lorenzo River at Big Trees was "corrected" for the presence of Loch Lomond Reservoir. This record was then extended back to 1921 from the beginning of the record in 1936 using statistical regression equations based on streamflow data for Arroyo Seco, rainfall at Wrights precipitation gage, and the preceding monthly flow at Big Trees. The streamflow record for Zayante Creek at Zayante was also synthesized from 1921 to 1979 using the extended record for San Lorenzo River at Big Trees. These extended streamflow records were used in the COUNTY MP and this master plan study for SCWD as a basis for other streamflow correlations.

Other relevant reports include Preliminary Review of of North Coast Water Supply (L-K, 1984), SCWD Urban Water Management Plan (L-H, 1985), Assessment of an Off-Stream Storage Water Supply Project on Baldwin Creek (Johnson/Butler, 1984), Water Rate and Fee Study (Brown and Caldwell, 1985, Santa Cruz-Monterey Counties Investigation (State of California, 1953), Fish Habitat Assessments for Santa Cruz County

<u>Streams</u>, (Harvey & Stanley Associates, 1982), <u>Scotts Valley Water Resources Management Plan</u> (David Keith Todd, 1988), and the previous master plan from 1963.

1.6 ABBREVIATIONS

The abbreviations shown in Table 1-1 are used in this report and the accompanying appendices in order to improve readability and conserve space. Also, a glossary of technical terms and a table for unit conversions are included in Appendices B and C, respectively.

Table 1-1
City of Santa Cruz Water Department
Water Master Plan

LIST OF ABBREVIATIONS

AF	acre-feet
AMBAG	Association of Monterey Bay Area Governments
ASF	assignable square feet
BS	booster station
C	Hazen-Williams friction loss coefficient
CFS	cubic feet per second
COUNTY MP	North Santa Cruz County Water Master Plan Study
Ct	contact time
CT	census tract
CY	cubic yard or calendar year
DOF	State Department of Finance
DU	dwelling unit
DWR	California State Department of Water Resources
DFG	California State Department of Fish and Game
EPA	US Environmental Protection Agency
FB	Felton Booster Station
FD	Felton Diversion
FGN	fixed grade node
FT	feet
FPS	feet per second
FY	fiscal year
GPD	gallons per day
GPM	gallons per minute
GHWTP	Graham Hill Water Treatment Plant
HGL	hydraulic grade line
HP	horsepower
IN	inch
JG&A	John Gilchrist & Associates
KW	kilowatt
KWH	kilowatt-hour
L&S	Luhdorff and Scalmanini Consulting Engineers
L-H	Leedshill-Herkenhoff, Inc.
L-K	Linsley, Kraeger Associates
LRDP	UCSC Long Range Development Plan
LUIS	City of Santa Cruz Land Use Information System
M&E	Metcalf and Eddy, Inc.
MCL	Maximum Contaminant Level
MPN	Most Probable Number
MG	million gallons
MGD	million gallons per day

mg/L	milligrams per liter
mL	milliliter
MI	mile
NC	North Coast
NOAA	National Oceanic and Atmospheric Administration
NTU	nephelometric turbidity unit
PG&E	Pacific Gas and Electric Company
PRV	pressure reducing valve
PSI	pounds per square inch
PSIG	pounds per square inch, gage
PVC	Polyvinyl chloride
SCWD	City of Santa Cruz Water Department
SLR	San Lorenzo River
SLVCWD	San Lorenzo Valley County Water District
SVWD	Scotts Valley Water District
TDH	total dynamic head
THM	trihalomethane
TZ	traffic zone
ug/L	micrograms per liter
UCSC	University of California at Santa Cruz
USEC	Santa Cruz County Urban Service Evaluation Criteria
USGS	U.S. Geological Survey
USL	Urban Services Line
VSD	variable speed drive
WTP	water treatment plant
WWTP	wastewater treatment plant
WY	water year
YR	year

table1.1/276c

Chapter 2

WATER DEMAND PROJECTIONS

2.1 INTRODUCTION

2.1.1 Background

The purpose of this chapter is to update water demand forecasts from the North County Water Master Plan (County MP) completed in 1984. The County MP derived a total water demand for the Santa Cruz Water Department (SCWD) and for other water agencies in north Santa Cruz County.

The County MP produced several reports on water demand in the north county, but none of these reports had sufficient, detailed documentation for use in updating SCWD's water demand. The County MP also produced a land use model and water demand model. The land use model was a spreadsheet file containing the number of residential units in 1983 for each traffic zone (TZ) in the unincorporated area only of the County MP study area, i.e., TZs within cities were not included. Using building permit data, the County Planning Department updated this model to 1985 only. The data were further adjusted by housing counts of the California Department of Finance (DOF).

The County MP water demand model was also a spreadsheet file with several categories of land use and water demand factors. The model was for the SCWD as a whole and was not disaggregated by TZ or census tract and thus was not usable for updating. Neither model has been maintained and updated with current land use and water consumption data.

Since the completion of the County MP in 1984, there have been a number of changes in the planning environment:

(1) A new population forecast by the Association of Monterey Bay Area Governments (AMBAG) to years 1990, 1995, 2000, and 2005, disaggregated to census tract (CT) and individual cities.

(2) An updated inventory of land uses compiled by the City of Santa Cruz Land Use Information System (LUIS).

(3) A survey of vacant, developable land in the City of Santa Cruz. This allowed an up-to-date determination of a buildout housing count.

(4) Development of a long range development plan (LRDP) by the University of California, Santa Cruz (UCSC)--The LRDP is being prepared for a range of year 2005 student enrollment of 12,000 to 15,000. Although still in draft form, the LRDP and its environmental

impact assessments provide several planning scenarios that differ from AMBAG forecasts.

(5) Adoption by the County Board of Supervisors of urban service evaluation criteria (USEC) for unincorporated areas--The criteria will be used to evaluate housing and commercial projects based on adequacy of urban services such as traffic, drainage, and sanitary sewer capacity; park service; and roadside improvements (curb and gutter). Water supply was not included as a criterion. The net effect would be to initially slow the growth of the unincorporated portion of the SCWD service area (primarily Live Oak) and thus provide another future growth scenario different from AMBAG forecasts.

(6) A change in planning environment in the SCWD service area--The County MP used an "ultimate service area" which was apparently in effect when the County MP was begun. This update will use an area essentially equal to the existing present service area, which is inside the ultimate area. This "inner line" was approved in concept for planning purposes by the City Council at its March 23, 1988 meeting. The line represents the area within which the SCWD can extend water services administratively, i.e., without special procedures from the City Council.

Since only a limited amount of data in the County MP and land use and water demand models are usable, and the planning environment has changed, the updated water demand forecast required an essentially new effort to collect and interpret data and information.

2.1.2 Basic Methodology

Water demand forecasting requires two major steps: (1) forecasting population, housing, and land use; and (2) deriving unit water use factors in gallons per day per person (gpd/person) gpd/dwelling unit (DU), or gpd/acre. Total water demand is composed of indoor residential, outdoor residential, commercial, industrial, and other (primarily irrigation) categories and is computed in this study as the product of the following.

Water demand category	Unit	Unit use factor
Residential		
Indoor	Population	gpd/person
Outdoor	No. of DU	gpd/DU
Non-residential		
Commercial	Area, gross acres	gpd/acre
Industrial	Area, gross acres	gpd/acre
Other	Area, gross acres	gpd/acre

UCSC		
Residential	No. of DU	gpd/DU
	No. of bedspaces	gpd/bedspace
Academic	Floor area, ASF*	gpd/ASF
Other (irrigation)	Area, sq ft	gpd/sq ft

*ASF = assignable square feet - a measure of floor area where employees usually work, such as offices and meeting rooms; excludes areas such as hallways, corridors, and storage areas.

This methodology is applied to the SCWD service area by (1) determining population, number of dwelling units, and non-residential land use separately for the unincorporated areas, the City of Capitola, and the City of Santa Cruz (excluding UCSC); and (2) deriving approximate unit use factors. UCSC water demand is in a separate category primarily because its housing (primarily group quarters) and land uses are different from other parts of the SCWD service area.

2.2 POPULATION AND HOUSING

Population and housing unit forecasts for the SCWD were derived for a base case and two other scenarios representing high and low growth projections.

2.2.1 Base Case

The base case scenario was based on the following information, data, and assumptions:

(1) AMBAG population forecast--The forecast is based on employment projections, birth and mortality rates, general plans, spheres of influence, vacant land, and status of infrastructure development. The forecast has been accepted by the City of Santa Cruz and is more or less an "official" figure.

The AMBAG forecast also includes UCSC enrollment of 12,200 students and a campus population of 7,720. The LRDP analysis of the off-campus population and housing impacts is based on the assumption that 55 percent of students and 8 percent of faculty/staff are living on campus. Further discussion of the LRDP methodology is in Section 2.2.2.

(2) For unincorporated areas, housing unit counts for 1983 in the County MP and land use model as updated by the County to 1985 for each TZ--The County MP developed a data base from various sources such as County Assessor's files, County Transportation Commission data, census data, and general plans. The data base was composed of land use information for each TZ in the County MP area and was eventually expanded to include the entire unincorporated area of the county. This information was summarized in a spreadsheet and

eventually became the aforementioned land use model. Specific information in the land use model was:

a. Total housing units in 1983, as developed in the County MP.

b. Total housing units in 1985, as updated by the County Planning Department.

c. Total housing units at buildout, as developed in the County MP.

Unfortunately, updates by TZ through 1987 were not done. Consequently, 1985 became the "current" year, i.e., the base year, for forecasting future housing and population. For each TZ, the 1985 housing unit total was the sum of the 1983 total and the number of building permits issued in 1984 and 1985. However, the 1985 total turned out to be 17.65% less than the the DOF total. The DOF figure was based on the 1980 U.S. Census and building permit data and was believed by the County Planning Department staff to be more accurate than assessor file data in the County MP. Consequently, for each TZ, total housing units were adjusted upward by a factor of 1.1765 to reflect the DOF total (see Table 2-1).

(3) For Capitola, the methodology was similar to that of the unincorporated area, except for the adjustment factor--The total number of housing units for the entire city as compiled in the County MP was within 5% of the DOF total for 1983: 4,738 in the County MP vs 4,981 DOF. Thus, no adjustment was made to the housing totals for the portion of the City of Capitola served by the SCWD and 1983 became the base year for Capitola (see Table 2-1).

(4) For the City of Santa Cruz, housing unit counts from LUIS were used. The City provided an up-to-date listing of land uses for each CT and block. The total housing count was slightly higher than the DOF totals for January 1, 1987 (see Table 2-2). The different dates of data collection probably account for much of this discrepancy. Another reason may be the manner in which housing at UCSC was counted. DOF data does not include much of UCSC's housing because it is considered group quarters; LUIS shows UCSC housing as multi-family dwellings. Since the totals without UCSC are so close (less than 3% difference), no adjustments were made and 1987 will be the base year for the City of Santa Cruz.

(5) Vacancy rates and persons/DU from the 1980 U.S. Census and annual DOF data since 1980. Persons/DU was projected to years 1990, 1995, 2000, and 2005 using 1980-1987 trends, except for the City of Santa Cruz, where the persons/DU was assumed to be 2.50 in year 2005 (from letter from Jane Weed, Mayor of Santa Cruz, to Nicholas Papadakis, Executive Director of AMBAG, October 19, 1987.) Trends

Table 2-1

City of Santa Cruz Water Department
Water Master Plan

CURRENT HOUSING UNITS
UNINCORPORATED AREA AND CAPITOLA

Area	1983 County MP	1984-85 No. permits	1985 total	1985 adjusted total 1/
Live Oak	8,337	528	8,965	10,547
Other urban	1,262	1	1,263	1,486
Other rural	19	0	19	22
Subtotal	9,618	529	10,247	12,056
Capitola	483	--	--	--

1/ Adjusted by 1.1765 based on DOF totals.

Table 2-2

City of Santa Cruz Water Department
Water Master Plan

RESIDENTIAL UNITS IN CITY OF SANTA CRUZ

	LUIS 10/87	DOF 1/1/87
Single family	10,470	11,807
Multi-family 1/		
2-3 units	2,751	--
2-4 units	--	2,398
4+ units	6,042	--
5+ units	--	4,471
Subtotal	8,793	6,869
Mobile homes	329	405
Total	19,592 3/	19,081

UCSC (group quarters) 1,831 2/

1/ Excludes group quarters.
2/ Shown in LUIS printout as multi-family units.
3/ Does not include group quarters.

generally show a steadily rising number of persons per household (see Table 2-3). Vacancy rates were assumed to be the same as in the 1980 U.S. Census (see Table 2-3).

Buildout. The number of DUs at buildout is based on current general plans and zoning. For the unincorporated areas, buildout DUs were taken directly from the County MP and land use model. The County MP derived buildout housing totals for the unincorporated area by two different methods. For rural areas (i.e., areas outside the urban services line (USL) defined in the County General Plan), the number of additional DUs at buildout for each TZ was the TZ area divided by the typical minimum parcel size, less any existing development. The typical minimum parcel size was determined by a procedure which considered density designations in the County General Plan land slopes and set-asides for riparian corridors. For urban areas (i.e., TZs within the USL), additional DUs at buildout were calculated as the product of vacant areas and and housing density in the County General Plan.

In the land use model, these additional units were added to the adjusted 1985 totals (i.e., including the 1.1765 factor) to obtain total DUs at buildout. No further adjustments were made since the County General Plan has not been changed significantly since completion of the County MP.

For Capitola, a buildout figure was derived using County MP data and information from the Capitola Planning Department.

For the City of Santa Cruz, buildout DUs were the sum of current DUs from LUIS and DUs allowed by current zoning on vacant land from the above-mentioned vacant land survey. That survey was based on a parcel-by-parcel evaluation of vacant residential land in each CT to consider its ability to be developed. Included in the evaluation were factors such as zoning, slope, accessibility, configuration of the parcel, and neighborhood compatibility. Not considered were the possibility of redevelopment or underutilization of existing developed parcels (capable of greater density of development).

Buildout totals for residential units are shown in Table 2-4.

Forecasts. Population forecasts for TZs in the unincorporated area and Capitola for years 1990, 1995, 2000, and 2005 are based on AMBAG population forecasts for CTs in which the TZs are located. Since base year (1985 or 1983) number of DUs is already known from the County MP (Table 2-1), base year population for the unincorporated area and Capitola is computed for each TZ using the following formula:

Population = No. DUs x persons/DU x (100% - vacancy rate)

For the City of Santa Cruz, base year (1987) and forecasted population are taken directly from the 1980 U.S. Census and AMBAG forecasts. Base year housing totals are from LUIS. For UCSC campus, population for base year

Table 2-3

City of Santa Cruz Water Department
Water Master Plan

PERSONS/HOUSEHOLD AND VACANCY RATES

	Persons/household 1/					Vacancy
	Current 2/	1990	1995	2000	2005	rate, % 3/
Live Oak	2.57	2.66	2.72	2.87	2.97	6.7
Other urban	2.33	2.40	2.47	2.55	2.62	4.9
Other rural	2.49	2.58	2.65	2.72	2.79	7.1
Santa Cruz	2.35	2.38	2.42	2.47	2.52	6.5
Capitola	2.10	2.12	2.15	2.18	2.21	9.0

1/ Based on the 1980 U.S. Census for each tract in the SCWD area and 1980-1987 trends as compiled by DOF for the unincorporated area, Capitola, and Santa Cruz.
2/ 1985 for Live Oak, other urban, and other rural; 1987 for Santa Cruz; 1983 for Capitola.
3/ From 1980 U.S. Census.

Table 2-4

City of Santa Cruz Water Department
Water Master Plan

RESIDENTIAL BUILDOUT FORECASTS

	Residential units		
	Current	Vacant	Buildout
Unincorporated			
Live Oak	10,547 1/	4,952	15,499 2/
Other urban	1,486 1/	685	2,171 2/
Other rural	22 1/	159	181 2/
Subtotal	12,056	5,796	17,852
Capitola	483 3/	56 4/	539
Santa Cruz 5/	19,592 6/	2,068 7/	21,660
Total	--	--	40,051

1/ Table 2-1 (base year 1985).
2/ County MP and land use model.
3/ Table 2-1 (base year 1983).
4/ Capitola Planning Department.
5/ Excluding UCSC.
6/ Table 2-2 (base year 1987).
7/ City vacant land use survey.

1985 was taken from unpublished studies for the LRDP (see Section 2.4). Forecasted on-campus population was also taken directly from AMBAG figures.

Except for UCSC, the forecasted number of DUs in each CT or TZ (Capitola, unincorporated, and Santa Cruz) is computed from the following formula:

No. DUs = population/[persons/DU x (100% - vacancy rate)]

UCSC housing is further discussed in Section 2.4.

In several CTs and TZs, housing buildout was projected to occur before year 2005. In such cases, if buildout were a true absolute maximum number of DUs and AMBAG forecasts apply, then persons/DU and/or vacancy rates for those areas would need to be unrealistic figures, e.g., persons/DU as high as 4 or 5 and vacancy rates at zero. A more realistic method is to allow the DU forecast to increase in proportion to population, persons/DU, and vacancy rate per the above formula, even though buildout figures may be exceeded.

The year 2005 DU forecast for some TZs in the unincorporated areas exceeds buildout, but is overall less than buildout. Except for Santa Cruz, residential buildout (pursuant to the existing general plan) would be reached before year 2000. For the SCWD service area as a whole, year 2005 DU forecasts are about 98% of buildout.

The results of the population and housing forecast for the SCWD service area are shown in Table 2-5.

2.2.2 High and Low Growth Scenarios

The base case scenario represents use of existing information and is essentially an extrapolation of historical trends. The use of alternative scenarios described in this section display the effect of different growth assumptions on the water demand. "High" and "low" growth scenarios were selected to provide a range of potential future water demands.

High Growth. The high growth scenario modifies the base case as follows:

(1) UCSC enrollment in year 2005 is 15,000 (instead of 12,200)--The effect of UCSC enrollment at 15,000 is to increase population throughout the SCWD area. The actual population and housing impacts have been estimated by UCSC as part of the LRDP environmental impact assessment. The basic assumptions are listed below.

Table 2-5

City of Santa Cruz Water Department
Water Master Plan

POPULATION AND HOUSING FORECASTS --BASE CASE

	Current 1/	Forecasts 1990	1995	2000	2005	Buildout 2/
Housing units 3/						
Unincorporated						
Live Oak	10,547	11,677	12,469	13,319	14,052	15,499
Other urban	1,486	1,532	1,609	1,612	1,615	2,171
Other rural	22	23	24	24	25	1,812
Subtotal	12,056	13,232	14,102	14,956	15,692	17,852
Capitola	483	496	508	517	526	539
Santa Cruz	19,592	20,254	20,911	21,975	23,088	21,660
Total	31,121	33,982	35,522	37,449	39,225	40,051
Population						
Unincorporated						
Live Oak	25,294	29,021	32,107	35,687	38,920	--
Other urban	3,287	3,502	3,782	3,905	4,026	--
Other rural	52	55	59	63	66	--
Subtotal	28,633	32,578	35,948	39,654	43,012	
Capitola	925	956	994	1,025	1,057	--
Santa Cruz 4/	43,085	45,076	47,423	50,788	54,171	--
Subtotal	72,642	78,610	84,365	91,467	98,240	--
UCSC	3,611	4,400	6,250	7,160	7,720	--
TOTAL	76,253	83,010	90,615	98,607	105,960	--

1/ Tables 2-1 and 2-2. 1985 for Live Oak, other urban, and other rural; 1987 for Santa Cruz; 1983 for Capitola. Totals are approximate.
2/ Table 2-4.
3/ Excludes group quarters and UCSC.
4/ Excludes UCSC.

a. Goals for housing students, faculty, and staff on campus will be met. Per the LRDP, these are:

- Undergraduate students, 70%
- Graduate students 50%
- Faculty 25%
- New support staff recruited from outside Santa Cruz County 50%

b. Each new student will generate 0.07 additional jobs (secondary employment).

c. Each new staff will generate 1.5 additional jobs (secondary employment).

d. Percent of students, faculty, and staff who are in-migrants to Santa Cruz County:

- Students 90%
- Faculty 95%
- Support staff 45%

e. Off-campus housing within SCWD will be distributed as follows:

	Students	Faculty and staff	Secondary employees
City of Santa Cruz	69%	60%	50%
Live Oak, Capitola	8%	10%	15%
Other areas	23%	30%	35%
Total	100%	100%	100%

f. Ten percent of all students have families and average family size is 2.66 persons. Each family student DU has 1.09 students. Seventy percent of faculty and staff have families of 2.90 persons. Single students living off-campus will be in DUs with 3.04 persons. Faculty, staff, and secondary employees living off-campus will be in households having 1.25 working persons. Each of these figures is based on UCSC data and may differ from comparable data for SCWD.

The overall effect of this 2,800 increase in enrollment over AMBAG's figure is summarized in the following tablulation.

Increase in year 2005 population over base case:

City of Santa Cruz	173
Unincorporated area, Capitola	93
Total	266

Increase in year 2005 DUs over base case:

City of Santa Cruz	63
Unincorporated area, Capitola	31
Total	94

The increase of only 266 population and 94 DUs for a 2,800 enrollment increase is less than expected, since UCSC's assumptions for 15,000 enrollment differ from those for AMBAG's 12,200 enrollment forecast. The primary differences are in assumptions about housing goals; the base case forecast, as presented in the LRDP, is based on a lower percentage of students, faculty, and staff housed on campus. Consequently, the base case forecasts show a relatively higher proportion of students, faculty, and staff living off-campus.

(2) Greenbelt areas within the City are developed in accordance with their underlying zoning (instead of remaining undeveloped open space under the current general plan).

There are three greenbelt areas within the City: Pogonip, Westlands (Younger), and Yacht Harbor (Kinsley). The Pogonip area is targeted for acquisition by the City and is thus not likely to be developed. The remaining two areas total 341 gross acres and their underlying zoning is primarily single-family residential. The theoretical maximum number of DUs which could be accommodated in these areas totals 651, as shown in Table 2-6. This figure does not consider potential constraints such as slopes, soil conditions, and other factors which could affect development. Based on persons/DU and vacancy rates in Table 2-3, the maximum population would be 1,522. The overall impact of these changes is shown in Table 2-7.

Low Growth. The low growth scenario modifies the base case information, data, and assumptions as follows:

(1) UCSC enrollment in year 2005 is 12,000 (instead of 12,200)--The effect of UCSC enrollment at 12,000 is to reduce population throughout the SCWD area. The actual population and housing impacts have been estimated by UCSC as part of the LRDP environmental impact assessment using the same basic assumptions as listed above for the high growth scenario except for student housing goals. At an enrollment of 12,000, it was assumed that

Table 2-6

City of Santa Cruz Water Department
Water Master Plan

BUILDOUT OF GREENBELT AREAS

	Area, acres			Minimum lot size,	Maximum
	Gross	Net 1/	Zoning	sq ft	No. DU
Westside	243	194	EA-20	20 acres	10
	48	36	R-1-5	5,000	314
Yacht harbor	50	37.5	R-1-5	5,000	327
Total	341	267.5			651
Total population					1,522 2/

1/ 75% of gross area for R-1-10 and R-1-5; 80% of gross area for EA-20.
2/ Based on 2.5 persons/DU and 6.5% vacancy rate in Table 2-3.

Table 2-7

City of Santa Cruz Water Department
Water Master Plan

SUMMARY OF HIGH GROWTH SCENARIO
YEAR 2005

	UCSC at 15,000 enrollment	Greenbelts at underlying zoning	Total
Increase in population over base case:			
Santa Cruz	173	1,522	1,695
Unincorporated area, Capitola	93	0	93
Total	266	1,522	1,788
Increase in DUs over base case:			
Santa Cruz	63	651	714
Unincorporated area, Capitola	31	0	31
Total	94	651	745

sufficient housing would be provided on campus to result in a zero net increase of in-migrating students housed off campus. Thus, the percentages of students housed on campus would be 63% for undergraduate students and 45% for graduate students.

The overall effect of this 200 decrease in enrollment from AMBAG's figure is summarized in the following tablulation.

Decrease in population over base case:

City of Santa Cruz	636
Unincorporated area, Capitola	86
Total	722

Decrease in DUs over base case:

City of Santa Cruz	218
Unincorporated area, Capitola	31
Total	249

For the same reasons as the high growth scenario, the overall effect is greater than expected, since UCSC's assumptions differ from those for the base case 12,200 enrollment forecast. The primary differences are in assumptions about housing goals; the base case forecast, as presented in the LRDP, is based on a lower percentage of students, faculty, and staff housed on campus. Consequently, AMBAG's forecasts show a relatively higher proportion of students, faculty, and staff living off-campus.

(2) Ten percent of the greenbelt areas within the City will be irrigated and have a water demand equal to 2.5 ac-ft/ac/yr (2,230 gpd/ac).

(3) Because of the USEC, growth to year 2005 in the unincorporated portion of SCWD (Live Oak and other urban only) as forecasted by AMBAG in Table 2-5 will be reduced as follows:

Period	% reduction in AMBAG growth	Decrease in Population	DU
Current-1990	50	1,971	589
1990-1995	50	3,650	1,023
1995-2000	25	4,580	1,236
2000-2005	0	4,580	1,236

This figure is based on estimates of (a) the extent of development which would have point scores high enough for approval and (b) the scheduling of future capital improvements in the area. Buildout figures would not change. The net effect of these changes is shown in Table 2-8.

Table 2-8

City of Santa Cruz Water Department
Water Master Plan

SUMMARY OF LOW GROWTH SCENARIO
Year 2005

	UCSC at 12,000 enrollment	USEC	Total
Decrease in population over base case:			
Santa Cruz	636	--	636
Unincorporated area, Capitola	86	4,580	4,666
Total	722	4,580	5,302
Decrease in DUs over base case:			
Santa Cruz	218	--	218
Unincorporated area, Capitola	31	1,236	1,267
Total	249	1,236	1,485

2.3 NON-RESIDENTIAL LAND USE

Non-residential land includes commercial, industrial, and other land uses such as schools, parks, golf courses, and other irrigated areas. For unincorporated areas and Capitola, base year (1983) non-residential land use was taken directly from the County MP. In the County MP, acreages were determined primarily though research and interviews. For the City of Santa Cruz, non-residential land use areas were taken from LUIS.

2.3.1 Buildout

For unincorporated areas, buildout acreages were taken directly from the County MP. County MP figures were obtained from a field survey of potentially developable areas, including vacant land and nonconforming parcels (i.e., homes on commercially zoned land). The sum of the current developed area (above) and the vacant and nonconforming parcel areas was the buildout area. This computation is probably still valid, since there have been no major revisions to the County General Plan since completion of the County MP.

In Capitola, based on interviews with the planning staff, virtually all of the remaining developable commercial land is in the Capitola Mall, which is currently under construction and expected to be completed in the next 1-2 years.

In Santa Cruz, vacant commercial and industrial land was compiled in the vacant land survey discussed in the previous section on population and housing. These figures plus existing land uses from LUIS equal buildout acreages.

Buildout totals of non-residential land use are shown in Table 2-9.

2.3.2 Forecasts

Non-residential land uses were forecasted using the following assumptions.

(1) Commercial land is wholesale and retail trade, and office uses such as banks, insurance, real estate, and other services. In general, the commercial category is considered population-serving, i.e., its products and services are designed for primarily local distribution. In other words, commercial acreage will be proportional to population growth. This assumption will be applied separately to the City of Santa Cruz and the unincorporated area of the SCWD. In Capitola, commercial land within SCWD service area is a regional shopping mall; thus, future commercial acreage will be proportional to growth of the entire SCWD service area.

(2) Industrial land use is essentially manufacturing and is considered basic employment, i.e., its products are for wider distribution

Table 2-9

City of Santa Cruz Water Department
Water Master Plan

NONRESIDENTIAL BUILDOUT FORECASTS

	ACRES		
	Current 1/	Vacant	Buildout
Commercial			
Unincorporated	119	29	148
Santa Cruz	732	29	761
Capitola	115	14	129
Subtotal	966	72	1,038
Industrial			
Unincorporated	133	7	140
Santa Cruz	143	47	190
Capitola	0	0	0
Subtotal	276	54	330
Other 2/			
Unincorporated	29	1	30
Santa Cruz	457	390	847
Capitola	3	0	3
Subtotal	489	391	880
Total			
Unincorporated	281	37	318
Santa Cruz	1,332	466	1,798
Capitola	118	14	132
Grand total	1,731	517	2,248

1/ For unincorporated area and Capitola, base-year 1983; for Santa Cruz, base year 1987.
2/ Primarily irrigated areas, such as parks, cemeteries, and highway medians.

throughout the County and state. Consequently, industrial land use will be proportional to AMBAG county-wide employment forecasts for durable and non-durable manufacturing.

(3) Forecasts for other land use will be the same as for commercial land.

The results of the non-residential land use forecast for the base case and high and low growth scenarios are shown in Table 2-10.

2.4 UNIVERSITY OF CALIFORNIA AT SANTA CRUZ (UCSC)

UCSC is currently developing its LRDP for year 2005 enrollments of between 12,000 and 15,000. As previously mentioned, goals for on-campus housing are:

Undergraduate students	70%
Graduate students	50%
Faculty	25%
New support staff recruited from outside Santa Cruz County	50%

These goals are expected to be met for the 15,000 enrollment scenario. But at an enrollment of 12,000, it was assumed that sufficient housing would be provided on campus to result in a zero net increase of in-migrating students housed off campus. Thus, the percentages of students housed on campus would be 63% for undergraduate students and 45% for graduate students.

The impact of these two scenarios on on-campus population and space needs is shown in Table 2-11. AMBAG figures, which are based on different housing goals for the campus, are also shown for comparison.

2.5 UNIT WATER USE FACTORS

Unit water use factors were developed for residential, commercial, industrial, and other land uses. These were calculated using population, DU, and water use data for the City of Santa Cruz. Population and DU data were available from LUIS and water use data from City meter book records. It was assumed that the unit water factors computed for the City applied to the remainder of the SCWD service area. Development of the basic unit water use factors is described in Sections 2.5.1 through 2.5.5. The basic factors represent the current unit water use for the respective land uses. The impacts of anticipated water conservation measures on the unit water use within <u>future development</u> are examined in Section 2.5.6. Factors for UCSC are also presented separately.

Table 2-10

City of Santa Cruz Water Department
Water Master Plan

NONRESIDENTIAL LAND USE FORECASTS
(acres)

	Current 1/	1990	1995	2000	2005	Buildout 1/
Base Case						
Commercial	966	1,015	1,032	1,038	1,038	1,038
Industrial	276	290	298	307	319	330
Other uses 2/	489	511	536	571	607	880
Total	1,731	1,816	1,866	1,916	1,964	2,248
High Growth						
Commercial	966	1,019	1,038	1,038	1,038	1,038
Industrial	276	290	298	307	319	330
Other uses 2/	489	514	541	580	618	880
Total	1,731	1,823	1,877	1,925	1,975	2,248
Low Growth						
Commercial	966	1,006	1,038	1,038	1,038	1,038
Industrial	276	290	298	307	319	330
Other uses 2/	489	491	500	520	541	880
Total	1,731	1,787	1,836	1,855	1,898	2,248

1/ Table 2-9.
2/ Primarily irrigated areas, such as parks, cemeteries, and highway medians.

Table 2-11

City of Santa Cruz Water Department
Water Master Plan

UCSC CAMPUS POPULATION AND FACILITIES FORECAST

	Current[1/]	Enrollment 12,000	12,200[2/]	15,000
Campus Population				
Single students	2,877	6,854	6,501	9,462
Family students	529	716	529	1,326
Faculty and staff	205	1,039	690	1,456
Total	3,611	8,609	7,720	12,244
Campus Facilities				
Core, campus support, ASF[3/]	625,362	1,213,016	--	1,604,706
Housing				
Colleges, No. beds	2,794	7,768	6,501	9,418
Family, No. DU's	199	379	216	499
Faculty, staff, No. DU's		294	296	457
Other buildings, ASF[3/]				
Physical education	38,044	111,873	--	161,092
Farm, arboretum	8,434	23,055	--	32,083
Playing fields (sq ft)	578,800	870,400	--	1,064,800

Note: Unless noted, based on LRDP as of August 1988

1/ Base year 1985-86 with enrollment of 7,500
2/ Based on AMBAG forecast for year 2005. Campus facilities not forecast for this enrollment by the LRDP.
3/ Assignable square feet. A measure of floor area where employees usually work, such as offices and meeting rooms; excludes areas such as hallways, corridors, and storage areas.

2.5.1 Residential

Residential unit water factors were calculated for the following classes:

Single Family Dwelling Units (SF)
- High Density (lot size 0.125 acre or less)
- Medium Density (lot size between 0.125 and 0.285 acre)
- Low Density (lot size 0.285 acre or greater)

Multiple Family Dwelling Units (MF)
- 2-4 units
- 5-9 units
- 10 + units

Mobile Homes

The procedure used to develop residential factors was to select a meter book area having primarily one of the above categories. Using LUIS data, the meter book was matched to a census tract and/or census blocks as closely as possible. For each category, three meter book areas were used.

An exception is mobile homes primarily because of insufficient data. Mobile homes are billed as businesses instead of residences and it was not possible to break out mobile homes from other businesses, since there are so few mobile homes in the City. Therefore, for mobile homes the unit water factors from the County MP were used.

Both indoor and outdoor unit factors were developed. Indoor water use was assumed to be the consumption for the wettest months, when outdoor uses such as irrigation and car washing would be minimized (usually January, February, or March). Outdoor use is then the difference between total (annual) consumption and indoor consumption. The most recent 12 months of water consumption data (December 1986 to November 1987) for each meter book were provided by the City. These data are divided into the following principal categories.

- Business
- Residential
- Multi-residential
- Industrial
- Other (including irrigation, interdepartmental, etc.)

For each area and category, a total (annual) and indoor unit factor were calculated as follows:

Total = annual consumption in gallons/No. DUs/365 days
Indoor = wettest 2 months consumption in gallons/No. DUs/60 days

The outdoor unit factor is the difference between the total and indoor factors. Indoor factors initially expressed in gpd/DU were converted to gal/day/person (gpd/capita) using persons/DU from the U.S. Census, to reflect the fact that indoor usage is a function of number of persons living in the DU. Outdoor factors are expressed in gpd/DU since outdoor use does not depend on number of people living in the DU. For each category, unit factors were computed for three meter book areas and the selected unit factors were a weighted average of the three meter book areas.

An example of this procedure is shown below for meter book area No. 56. This area was found to match census tract 1009 and block No. 5 which had have mostly high density SF DUs. The following tabulation illustrates the calculation for this area.

	No. of	Annual water use		Indoor water use	
Category	SFDU	100 cf/yr	gpd	100 cf/2 mo.	gpd
High density	126				
Med density	14				
Low density	1				
Total	141	12,496	25,608	1,552	19,031

Total unit factor = (25,608/141) = 182 gpd/DU

Indoor unit factor = (19,031/141) = 135 gpd/DU or at 2.14 persons/DU, 63 gcd.

Outdoor unit factor = 182 - 135 = 47 gpd/DU

Residential unit water factors are shown in Table 2-12.

2.5.2 Commercial

The process for calculating the commercial unit water use factors was similar to that used for calculating the residential factors. The commercial factors were calculated for these LUIS categories:

Transportation	Retail
Restaurants	Services/offices
Government	Hotel/motel/bed & breakfast
Cultural facilities	Recreation

The unit water use factors were calculated using business or other water use categories (such as interdepartmental for government) for a certain area with the number of commercial acres in that area. Just as with residential, census tracts and blocks from LUIS were matched to specific meter book routes. Indoor and outdoor water demand factor was then calculated, using

Table 2-12
City of Santa Cruz Water Department
Water Master Plan

RESIDENTIAL UNIT WATER USE FACTORS

Land Use Type	Citywide Total # DU's	Census Tract	Meter Book(s)	Units	Total Use			Indoor Use			Outdoor Use
					gud	Persons/DU	gcd	gud	Persons/DU	gcd	gud
Single Family, High Density											
		1008	55	162	227	2.13	106	175	2.13	82	52
		1009	56	126	182	2.14	85	135	2.14	63	47
		1011	21	203	230	2.53	91	172	2.53	68	58
Average/Total	3,336			491	217		95	163		71	53
Single Family, Medium Density											
		1001	44,47	341	330	2.95	112	212	2.95	72	118
		1002	45,46	390	277	2.34	118	179	2.34	76	98
		1012	11	159	269	2.88	93	194	2.88	67	75
Average/Total	6,288			890	296		111	194		73	102
Single Family, Low Density											
		1003	4	93	790	2.79	283	290	2.79	104	500
		1005	6	79	330	2.69	123	221	2.69	82	109
		1002	40	41	295	2.34	126	98	2.34	42	197
Average/Total	846			213	524		193	227		94	297
Multiple Family, 2-4 Units											
		1006	16	57	276	2.49	111	227	2.49	91	49
		1001	41,44,47	40	174	2.95	59	129	2.95	44	45
		1008	54	123	177	2.13	83	131	2.13	61	46
Average/Total	2,751			220	202		86	156		66	47
Multiple Family, 5-9 Units											
		1010	21	52	147	2.07	71	133	2.07	64	14
		1008	49,52	75	208	2.13	98	220	2.13	103	(12)
		1009	56	56	289	2.14	135	71	2.14	33	218
Average/Total	1,292			183	215		101	150		71	66
Multiple Family, 10+ Units											
		1011	23	--	--	--	--	--	--	--	0
		1003	4	--	--	--	--	--	--	--	0
		1005	1	183	170	2.69	63	154	2.69	57	16
Average/Total	5,702			183	170		63	154		57	16
Mobile Home											
Average/Total	329	1011	24	329	150	1.60	94	100	1.60	63	50
Residential Average	20,544				238		94	170		68	68

the same procedure as for residential except that acres instead of population or DUs were used to give gallons per acre per day (gpd/acre).

Several water use factors were calculated for each commercial category. The selected commercial unit factor is a weighted average based on number of commercial acres in each area. The results are shown in Table 2-13.

2.5.3 Industrial

Industrial unit water factors were calculated the same way as commercial water demand factors, but using industrial water use data. The following LUIS categories were used:

Food Products
Manufacturing
Electronics

The results of these calculations are shown in Table 2-13. The weighted average of 357 gpd/acre is very low compared to factors in other areas. The industrial water demand factors were recalculated using the largest water users from the County MP. Data was also obtained from the City for four of the largest industrial water users in recent years. The addresses of these water users were used to find their lot sizes in LUIS. The water use for these users was then divided by their lot sizes to calculate the industrial water demand factor. As shown in Table 2-14, the unit factors varied widely, by as much as two orders of magnitude. The selected unit industrial factor was the median of the values.

2.5.4 Other Uses

The process for calculating the other uses unit water factors was similar to that used for calculating the residential and commercial factors. The other uses water use factors were calculated for these LUIS categories:

Park
Cemeteries
Agriculture

The water use factors were calculated by comparing 1987 irrigation and other water use category data for a certain area with the number of acres in that area. Several water demand factors were thereby calculated for each other category, and once again were averaged using a weighted average. The results are shown in Table 2-13.

2.5.5 Comparison with Other Studies

All the unit water use factors, unadjusted for anticipated impacts of conservation measures (see Section 2.5.6), are summarized in Table 2-15. Also in Table 2-15 is a comparison of the these unadjusted or "current" factors

Table 2-13
City of Santa Cruz Water Department
Water Master Plan

NON-RESIDENTIAL UNIT WATER USE FACTORS

Land Use Type	Number	Units	Unit Use Factors (Gallons/Unit/Day) Total	Indoor	Outdoor
INDUSTRIAL					
Food Products	54.52	Acres	397	267	130
Manufacturing	44.2	Acres	1,408	554	854
Electronics	44.71	Acres	329	185	144
AVG/TOTAL Industrial, 1/			687	330	357
COMMERCIAL					
Transportation	265.27	Acres	2,491	1,874	617
Retail	124.27	Acres	1,944	1,867	77
Restaurants	24.79	Acres	14,515	13,786	729
Services/Offices	271.79	Acres	558	428	130
Government	1034.9	Acres	436	200	236
Hotel/Motel/B&B	20.96	Acres	8,539	6,845	1,694
Cultural Facilities	23.95	Acres	9,681	---	---
Recreation	28.5	Acres	2,967	---	---
AVG/TOTAL Business	1741.98		1,315	989	326
OTHER USES					
Park	242.76	Acres	885	---	---
Cemeteries	81.29	Acres	487	---	---
Agriculture	81.29	Acres	4,716	---	---
AVERAGE/TOTAL	405.34		1,573		

1/ See Table 2-14 for additional data on industrial factors.

Table 2-14
City of Santa Cruz Water Department
Water Master Plan

INDUSTRIAL UNIT WATER USE FACTORS

Industry	Current use gpd 1/	Area, acres 2/	Unit factor gpd/ac
A	349,814	1,032	339
B	186,614	2.03	91,928
C	48,042	14.84	3,237
D	29,684	7.68	3,865
E	24,120	6.69	3,605
F	20,395	21.79	936
G	15,570	0.24	64,874
H	2,852	3.44	829
I	20,328	2.03	10,014
J	17,526	7.68	2,282
K	25,680	0.45	57,067
Median	—	—	3,600

1/ From County MP or City of Santa Cruz Water Department
2/ From LUIS

Table 2-15
City of Santa Cruz Water Department
Water Master Plan

COMPARISON OF WATER DEMAND FACTORS

Type of User	Unit	SCWD Master Plan 1/	County MP	Alameda County Water District	City of Milpitas
Residential					
Indoor	Gal/person/day	68	61	--	--
Outdoor	Gal/person/day	26	47	--	--
Total	Gal/person/day	94	108	99-110	110
Indoor	Gal/unit/day	170	122	--	--
Outdoor	Gal/unit/day	68	95	--	--
Total	Gal/unit/day	238	217	--	--
Commercial	Gal/acre/day	1,300	1,283	--	2000-3000
Industrial	Gal/acre/day	3,600	1,567	536-5360	3000-7500
Other	Gal/acre/day	1,570	2,200	--	3,000

1/ From Table 2-12 and 2-14

with those for other areas and with the County MP. Minor differences are probably because of climate, persons/DU, land uses, or levels of conservation.

2.5.6 Impacts of Conservation Measures

Water demands for future development are often projected by multiplying anticipated land use or population estimates by the average unit use factors for current development. However, direct application of current averages to future development can sometimes produce an error in the water demand projections. Conservation measures, technological improvements, State laws, and water management policies can often result in lower unit use factors for future development than for similar existing development since existing areas would tend to have older, inefficient plumbing and appliances as well as large turf areas and high water-using plantings. Therefore, in order to accurately assess future water demands, the impact of the various water management and conservation measures should be evaluated.

The SCWD's successful ongoing programs in water management and conservation were reviewed in LH's Urban Water Management Plan dated October 1985. These efforts have been effective in maintaining water use below pre-1977 levels. Further conservation measures are being evaluated on a continuing basis by SCWD.

In addition to the SCWD's programs, consideration must be given to technological improvements such as more efficient toilets and plumbing fixtures, automated irrigation systems, and the increasing popularity of low water-using landscape materials. These measures have an impact of lowering average water use per dwelling unit or per acre for future development without any formal action on the part of the water purveyor.

The conservation measures anticipated to affect the unit water use of future development were described in a report from the Director of the SCWD to the City Water Commission dated March 30, 1988. This report outlined a set of potential water conservation measures which are intended to be applicable to all new construction and time-of-sale retrofit for all types of land use. The measures are aimed at reducing both indoor and outdoor use in future development.

Of the measures outlined in the Director's report, only those measures with a realistic chance of being implemented and effective were considered. For example, the time-of-sale retrofit and landscape restrictions were not anticipated to be enacted in the foreseeable future. Based on input from SCWD staff, it has been assumed for the purposes of this study that (1) only indoor residential water use in future development will be significantly impacted and (2) Santa Cruz County would follow the SCWD's lead and enact identical water conservation ordinances for the unincorporated portions of the SCWD service area. Therefore, the following measures related to indoor

residential water use are assumed to be effective for all future development within the SCWD service area:

(1) installation of ultra low-flush toilets (1.5 gpm) in all new construction, including remodels and additions;

(2) installation of low-flow showerheads (2.75 gpm) in all new construction, including remodels and additions;

(3) use of water-efficient appliances in all new construction, including remodels and additions;

Although some of these measures would tend to reduce use within existing residential development, increasing household densities (i.e., persons per household) are assumed to offset any such reductions. Therefore, the unit use factor previously shown in Table 2-15 for indoor residential use will be maintained for existing development.

Based on assumed breakdowns of total indoor water use, published estimates of water use for various plumbing fixtures, and the aforementioned water conservation measures, the unit water use factors to be applied in computing the total annual water use of <u>future</u> development were calculated as shown in Table 2-16. The estimates of total current use, which were derived from recent meter book records, were presented in Table 2-15.

As indicated in Table 2-16, projected reductions were conservatively estimated at 30 percent for toilet use, 10 percent for shower use, and 5 percent for appliances. These reductions in indoor water use for future residential development are expected to yield a total unit demand of about 19 percent lower than the current average, resulting in a unit use factor of 138 gal/unit/day.

2.5.6 UCSC

UCSC has derived its own unit water factors based on work done for the LRDP. Using 1985-86 as its base year, the factors were derived for each category of facility in Table 2-11. Also derived were conservation or mitigation measures for each category. The mitigation measures are based on the following assumptions for future growth only; current water use is assumed to remain the same.

Unit water factors for UCSC are shown in Table 2-17.

2.6 FORECASTED WATER DEMAND

Water demand for the SCWD service area for both high and low growth scenarios in year 2005 is shown in Tables 2-18 through 2-21. The demand includes an amount for "unaccounted for" water, which is water used for flushing, unmetered water or under-registration of meters, Water Department usage, and leaks. The percentage used, 4%, is based on data after 1982 when the SCWD implemented its leak detection program.

Table 2-16

City of Santa Cruz Water Department
Water Master Plan

IMPACTS OF CONSERVATION MEASURES ON UNIT FACTORS
FOR INDOOR RESIDENTIAL USE

WATER USE	PERCENT OF TOTAL INDOOR USE	CURRENT AVERAGE USE (gal/unit/day)	ESTIMATED PERCENT REDUCTION	FUTURE AVERAGE USE (gal/unit/day)
Toilet Use	50%	85	30%	60
Shower Use	35%	60	10%	54
Appliances	15%	25	5%	24
Total Indoor Residential	100%	170	19%	138

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Table 2-17
City of Santa Cruz Water Department
Water Master Plan

UCSC CAMPUS USE UNIT WATER FACTORS

	Unit	Unit factors Indoor	Outdoor
BASE WATER USE			
Core & campus support buildings	gpd/ASF	0.10	0.04
College & grad. housing	gpd/bed	73	10
Family housing	gpd/DU	198	73
Faculty, staff housing	gpd/DU	217	80
P.E. buildings	gpd/sq ft	0.16	—
P.E. playing fields	gpd/sq ft	—	0.04
Farm & arboretum buildings	gpd/sq ft	0.12	—
MITIGATION/CONSERVATION MEASURES			
Library air conditioning	gpd	10,800	—
College coolers	gpd	27,000	—
Low-flow toilets 1/			
College & grad. housing	gpd/bed	3.0	—
Family housing	gpd/DU	8.0	—
Faculty, staff housing	gpd/DU	7.5	—
Day use, faculty & staff	gcd	2.0	—
Day use, students	gcd	2.0	—
Low-flow showerheads 2/			
College & grad. housing	gpd/bed	6.4	—
Family housing	gpd/DU	17.1	—
Faculty, staff housing	gpd/DU	16.1	—
Landscape irrigation 3/			
Core & campus support buildings	gpd/ASF	—	0.0052
College & grad. housing	gpd/bed	—	1.2
Family housing	gpd/DU	—	9.1
Faculty, staff housing	gpd/DU	—	10.0

1/ Based on 1 gal/flush; 3 flushes/day/person for campus residents or 2 flushes/day/person for day students, faculty, and staff.

2/ Based on 7.5 gal/shower (1.5 gpm for 5 minutes) and 0.86 showers/day/person for campus residents only.

3/ Based on 12.5% of current use factor.

Table 2-17
City of Santa Cruz Water Department
Water Master Plan

UCSC CAMPUS USE UNIT WATER FACTORS

	Unit	Unit factors Indoor	Outdoor
BASE WATER USE			
Core & campus support buildings	gpd/ASF	0.10	0.04
College & grad. housing	gpd/bed	73	10
Family housing	gpd/DU	198	73
Faculty, staff housing	gpd/DU	217	80
P.E. buildings	gpd/sq ft	0.16	—
P.E. playing fields	gpd/sq ft	—	0.04
Farm & arboretum buildings	gpd/sq ft	0.12	—
MITIGATION/CONSERVATION MEASURES			
Library air conditioning	gpd	10,800	—
College coolers	gpd	27,000	—
Low-flow toilets 1/			
College & grad. housing	gpd/bed	3.0	—
Family housing	gpd/DU	8.0	—
Faculty, staff housing	gpd/DU	7.5	—
Day use, faculty & staff	gcd	2.0	—
Day use, students	gcd	2.0	—
Low-flow showerheads 2/			
College & grad. housing	gpd/bed	6.4	—
Family housing	gpd/DU	17.1	—
Faculty, staff housing	gpd/DU	16.1	—
Landscape irrigation 3/			
Core & campus support buildings	gpd/ASF	—	0.0052
College & grad. housing	gpd/bed	—	1.2
Family housing	gpd/DU	—	9.1
Faculty, staff housing	gpd/DU	—	10.0

1/ Based on 1 gal/flush; 3 flushes/day/person for campus residents or 2 flushes/day/person for day students, faculty, and staff.

2/ Based on 7.5 gal/shower (1.5 gpm for 5 minutes) and 0.86 showers/day/person for campus residents only.

3/ Based on 12.5% of current use factor.

Table 2-19
City of Santa Cruz Water Department
Water Master Plan
YEAR 2005 WATER DEMAND WITHOUT UCSC 1/
Low Growth Scenario

	Population 2/	Dwelling units 2/	Area, acres 3/	Unit water factors 4/ gcd	gud	gad	Total demand gpd	mil gal/yr
Residential								
Current development	72,642	32,131		68	68		7,124,577	2,600
Additional development								
Base case	25,598	7,095		53	68		1,832,815	669
UCSC off campus, USEC	(4,111)	(1,485)		53	68		(317,844)	(116)
Subtotal	94,130	37,740					8,639,548	3,153
Commercial								
Current development			967			1,249	1,207,577	441
Additional development			71			1,249	89,065	33
Subtotal			1,038				1,296,662	473
Industrial								
Current development			276			3,420	943,920	345
Additional development			43			3,420	145,931	53
Subtotal			319				1,089,851	398
Other								
Current development			489			1,416	692,306	253
Additional development			93			1,416	131,154	48
Greenbelt			34			2,232	76,101	28
Subtotal			616				899,561	328
Total							11,925,622	4,353

NOTE: some columns may not add because of rounding.

1/ Does not include UCSC or unaccounted for water -- see Tables 2-20B and 2-21.

2/ Tables 2-5 and 2-8.

3/ Table 2-10.

4/ Table 2-16.

Table 2-20A
City of Santa Cruz Water Department
Water Master Plan
UCSC WATER DEMAND
BASE YEAR (1986)

	No. of units 1/	Unit factor gpd 2/	Total demand gpd	Total demand mil gal/yr
Core & campus support bldgs, ASF 3/	625,362	0.14	90,383	33.0
College & grad housing, beds	2,794	83	231,683	84.6
Family housing, DU's	199	271	53,921	19.7
Faculty, staff housing, # DU's	49	297	14,568	5.3
P.E. buildings, ASF 3/	38,044	0.16	6,219	2.3
P.E. playing fields, sq ft	578,800	0.04	22,690	8.3
Farm & arboretum buildings, ASF 3/	8,434	0.12	998	0.4
Farm project			17,762	6.5
Arboretum			4,312	1.6
Garden			2,927	1.1
Swimming pools			782	0.3
Other			1,889	0.7
Total			448,134	163.6

1/ Table 2-11.
2/ Table 2-17.
3/ Assignable square feet.

Table 2-20B
City of Santa Cruz Water Department
Water Master Plan
UCSC WATER DEMAND

	Enrollment = 12,000				Enrollment = 15,000			
	No. of units 1/	Unit fact gpd 2/	Total demand gpd	Total demand mil gal/yr	No. of units 1/	Unit fact gpd 2/	Total demand gpd	Total demand mil gal/yr
BASE WATER USE								
Core & campus support bldgs,ASF 3/	1,213,016	0.14	175,316	64	1,604,786	0.14	231,938	85
College & grad housing, beds	6,768	83	561,247	205	9,418	83	780,956	285
Family housing, DU's	379	271	102,694	37	499	271	135,209	49
Faculty, staff housing, # DU's	294	297	87,349	32	457	297	135,870	50
P.E. buildings, ASF 3/	111,873	0.16	18,289	7	161,092	0.16	26,335	10
P.E. playing fields, sq ft	870,400	0.04	34,120	12	1,064,800	0.04	41,741	15
Farm & arboretum buildings, ASF 3/	23,055	0.12	2,727	1	32,803	0.12	3,880	1
Farm project			46,181	17			53,286	19
Arboretum			11,211	4			12,935	5
Garden			2,927	1			2,927	1
Swimming pools			4,282	2			5,834	2
Subtotal			1,046,344	382			1,430,912	522
MITIGATION/CONSERVATION MEASURES 4/								
Library air conditioning			10,800	4			10,800	4
College coolers			27,000	10			27,000	10
Low-flow toilets								
College & grad housing, beds	3,974	3.0	11,923	4	6,624	3.0	19,872	7
Family housing, DU's	180	8.0	1,436	1	300	8.0	2,394	1
Faculty, staff housing, # DU	245	7.5	1,836	1	408	7.5	3,060	1
Day use, faculty & staff	1,339	2.0	2,678	1	2,307	2.0	4,614	2
Day use, students	4,503	2.0	9,006	3	7,503	2.0	15,006	5
Low-flow showerheads								
College & grad housing, beds	3,974	6.4	25,550	9	6,624	6.4	42,583	16
Family housing, DU's	180	17.1	3,078	1	300	17.1	5,130	2
Faculty, staff housing, # DU	245	16.1	3,934	1	408	16.1	6,557	2
Landscape irrigation								
Core, campus support bldgs,ASF 3/	587,654	0.0052	3,048	1	979,424	0.0052	5,080	2
College & grad housing, beds	3,974	1.2	4,861	2	6,624	1.2	8,102	3
Family student housing, DU's	180	9.1	1,646	1	300	9.1	2,743	1
Faculty, staff housing, DU's	245	10.0	2,456	1	408	10.0	4,094	1
Subtotal			109,253	40			157,035	57
NET TOTAL			937,090	342			1,273,877	465

1/ Table 2-11.
2/ Table 2-17.
3/ Assignable square feet.
4/ Future development only.

Table 2-21
City of Santa Cruz Water Department
Water Master Plan

SUMMARY OF YEAR 2005 WATER DEMAND

	High Growth Scenario		Low Growth Scenario	
	MG/day	MG/year	MG/day	MG/year
SCWD without UCSC 1/	12.36	4,513	11.93	4,353
UCSC 2/	1.27	465	0.94	342
Subtotal	13.64	4,978	12.86	4,695
Unacounted for water 3/	0.55	199	0.51	188
Total	14.18	5,177	13.38	4,883

1/ Table 2-18 or 2-19.

2/ Table 2-20.

3/ Based on 4 percent of subtotal.

Chapter 3

WATER DISTRIBUTION SYSTEM

3.1 INTRODUCTION

This chapter presents results of the evaluation of the existing water distribution system, using future demands derived in Chapter 2. The evaluation included updating the current computer model; running the model with year 2005 demands and determining deficiencies; and listing the improvements needed.

3.2 UPDATE OF COMPUTER MODEL

3.2.1 New Facilities

The City of Santa Cruz has been using a water distribution system computer model developed by Metcalf & Eddy (WADSY) since 1977. This model was recently updated by SCWD to reflect current conditions such as new pipelines, storage tanks, pumping stations (e.g. Pasatiempo), and new valve operations involving the isolation of Upper and Lower Pasatiempo.

3.2.2 Demand Distribution

Year 2005 water demands for the high growth scenario were computed for each census tract or traffic zone using a two-step procedure. First, the residential base case demands were computed for each census tract or traffic zone using disaggregated population and housing data and unit factors in a manner similar to Table 2-18. Except for the greenbelt development, the increment of growth for the high growth scenario (Tables 2-7 and 2-10) could not be disaggregated to census tract or traffic zone. Instead, the water demand for the high growth increment was allocated to census tracts within the City of Santa Cruz in proportion to area of vacant land in that tract. For unincorporated areas, the increment was allocated evenly to census tracts.

Industrial, commercial, and other water demands for both base case and high growth increment were allocated to census tracts in a similar manner. As in Table 2-21, 4 percent of the subtotal was added to reflect "unaccounted for" water.

Once demands for each census tract were computed, the demands were further allocated proportionately to nodes in the WADSY model. Each node was assigned a factor based on its "tributary" area and whether it was entirely within one census tract or split between/among several. These factors were then used to assign each node a water demand.

3.3 HYDRAULIC ANALYSES

The objective of the hydraulic analysis is to determine if the system can deliver water to customers at adequate pressures at all times. The critical test consists of applying peak flows to evaluate system behavior at extreme, stressed conditions. Generally, two such conditions are used: maximum daily flows plus fire flows; and peak hourly flows.

3.3.1 Maximum Daily and Fire Flows

In the first case, the WADSY model was run with maximum daily future demands only. From historical production data, maximum daily demands are generally 1.4 to 1.7 times average daily demands. For this model run, a peak factor of 1.7 was used. Areas showing residual pressures of less than 30 psi and/or pipe headlosses greater than 10 ft/1000 ft are considered "weak" areas. These areas were subjected to further investigation for adequacy to provide fire flows at 20 psi residual. A boundary condition of 20 psi was input to the model and the computed flows were evaluated for adequacy for fire protection.

The model results showed no low pressure nodes but did reveal several locations with high headlosses in pipes. These areas included:

(1) Bay and King Streets downtown
(2) Mission Street downtown
(3) Soquel Dr. and Thurber Lane in north Live Oak
(4) Check valve on La Fonda Ave.
(5) Next to Beltz Treatment Plant
(6) East Cliff Dr. & Ocean View Park - east bank San Lorenzo River

The area next to the Beltz Treatment Plant is close to a water supply source, so that the high head losses were considered acceptable. The model was run with boundary conditions of 20 psi at the other locations (the Mission Street and Bay & King Streets were close enough to run one fire flow). The model computed the following flows at 20 psi residual:

(1)	Bellevue St. and Mission St.	3,365 gpm
(2)	Soquel Dr. and Thurber Lane	3,490 gpm
(3)	La Fonda Ave. and Soquel Avenue	7,685 gpm
(4)	East Cliff Dr. and Ocean View Park	5,670 gpm

All of these flows are more than adequate for fire protection so that the system should deliver future maximum day demands and fire flows.

3.4.2 Peak Hour

The second stressed condition is peak hourly flows. From past data (Brown and Caldwell, 1963), the peak hour flow was found to be 310% of average

daily demand. The test criteria are the same as for maximum daily flows: areas showing residual pressures of less than 30 psi and/or pipe headlosses greater than 10 ft/1000 ft are considered "weak" areas. The model's results indicated low pressures and high headlosses in two areas: the north half of the Live Oak, generally north of Capital Avenue; and the western end of the service area.

The low pressures and high headlosses are the result of high growth and inadequate pipeline capacity in Live Oak. As shown in Table 2-5, about half of the population and housing unit growth has been forecasted to occur in the unincorporated portion of the SCWD service area. However, the pipeline network in the unincorporated ares, which, is not as dense as within the City, if not adequate to convey the additional water to the area from the Graham Hill Water Treatment Plant (GHWTP). South of Capitola Avenue, pressures and head losses are adequate because of the Beltz wells. The north boundary of the Beltz well zone of influence is about at Brommer Avenue, so that the north part of Live Oak would not be served by Beltz under this scenario.

A similar but not as severe situation revealed by the model results is in the western area. Most of the growth in this area is new industry and residential development in the westside greenbelt area which occurs under the high growth scenario described in Chapter 2 (Table 2-6). The pipeline capacities along Mission and King Streets and on Western Drive are not adequate to serve this new growth.

The WADSY model was also run at peak hourly flows with a new 1-mgd well at Thurber Lane and Kenny (see Chapter 7). The results were similar to those discussed above. The modeled pressures in the Live Oak area were about 2 to 3 psi higher with the new well but still below acceptable levels (see Table 3-1).

3.5 RECOMMENDED IMPROVEMENTS

3.5.1 Distribution Mains

Based on the WADSY analysis, the following new pipelines (in addition to existing pipelines) would alleviate pressure problems in the Live Oak area (see Table 3-1, Figure 3-1).

Location	Length ft	Size in
Water, May to Morrissey	3,900	12
Soquel Ave, 7th Ave to Mattison	4,300	14
Soquel Ave, Mattison to 41st Ave	3,200	12
Mattison, Soquel Ave to Maciel	1,800	8
Delaveaga Reservoir to Mission and Twin Hills	3,200	12
Mission and Twin Hills, along Mission and Thurber to Soquel Dr	1,900	10
Soquel Dr., Mission to Thurber	700	12
Soquel Dr., Thurber to Chanticleer	300	10

Table 3-1
City of Santa Cruz Water Department
Water Master Plan
YEAR 2005 PEAK HOURLY PRESSURES

Pressures in psi

Location	Without new Thurber Well		With new Thurber Well	
	Without improvements	With improvements	Without improvements	With improvements
Soquel & 41st	13	33	15	34
Soquel & Thurber	29	48	33	50
Mattison & Soquel Dr.	14	34	17	35
Mattison & Soquel Ave.	17	37	20	38
41st & Gross Rd.	26	46	29	48
Clares & 41st	27	46	30	48
Maciel & Mattison	26	44	28	46
Capitola Mall	26	44	28	46
Capitola Mall	27	46	30	47
Clares & 40th	28	47	31	48
Chanticleer & Soquel	25	46	29	48
Rodeo Gulch & Soquel	14	34	17	36
Caldwell & Rodeo Gulch	11	31	14	33
Rodeo Gulch	16	36	19	37
Cory & Research Park	15	34	16	37
Hillcrest Research Park	12	32	15	33
Caldwell & Research Park	12	32	15	33
Soquel Dr. & Hillcrest R.P.	10	30	13	31
Cory & 41st	14	34	17	35
Auto Plaza Dr.	24	44	27	46
Mission & Schaffer	—	—	20	42
Western & Echo	—	—	29	31

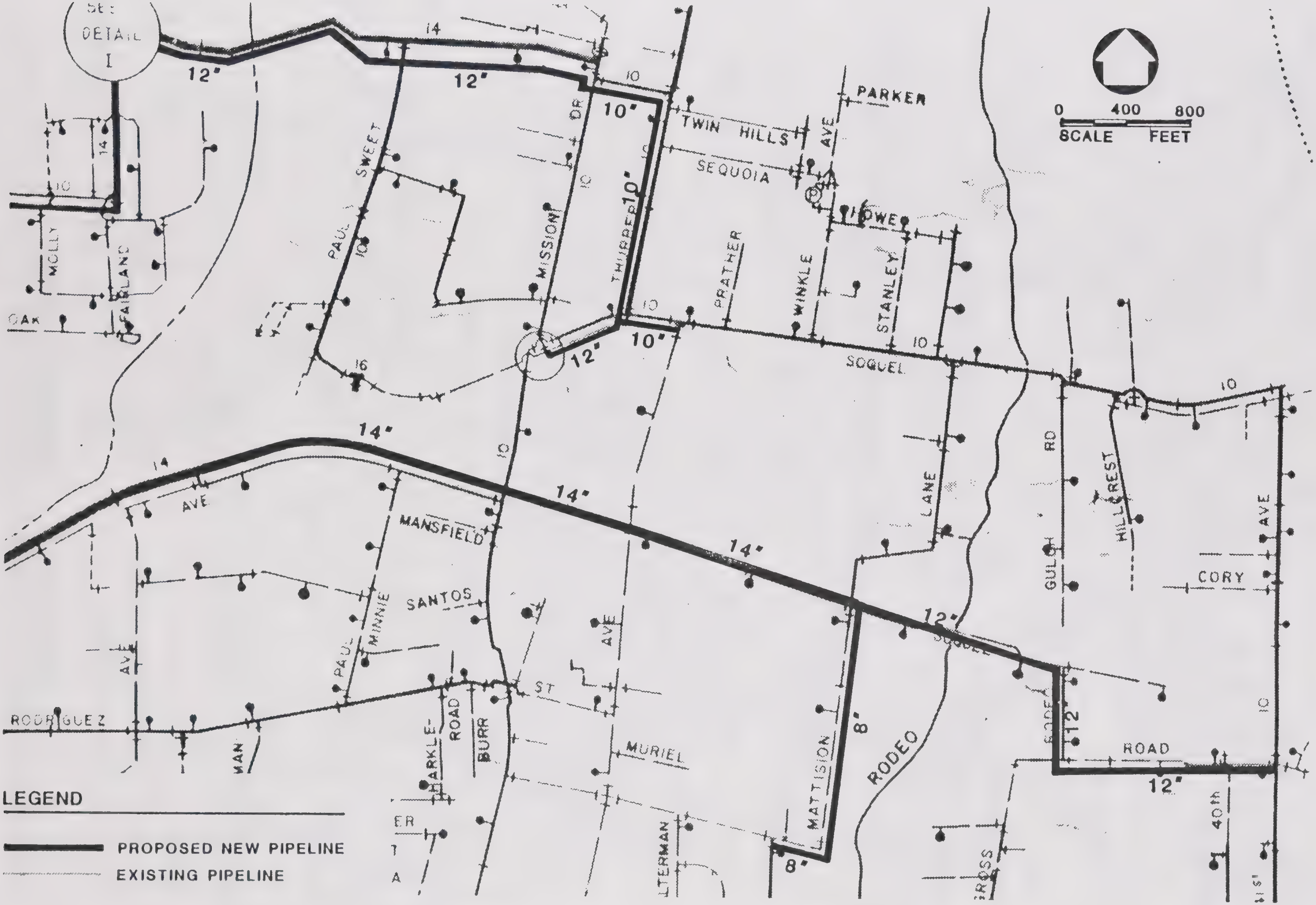


FIGURE 3-1.
PROPOSED NEW WATER MAINS FOR LIVE OAK AREA

FIGURE 3-1. (CONCLUDED)
PROPOSED NEW WATER MAINS FOR LIVE OAK AREA

For the westside, new pipelines would depend on whether the newly developed greenbelt area was served by the gravity system (GHWTP and/or Bay Street Reservoir) or by the University system. In the first case, the following new lines (in addition to existing pipelines) would lower headlosses and raise pressures to acceptable levels (Table 3-1, Figure 3-2).

Location	Length ft	Size in
King, Bay to Escalona	2,600	12
Mission, Bay to Baldwin	1,000	12

In the second case, a new pipeline network off Western Drive would need to be built. For purposes of this analysis a new grid was approximated by completing a loop from Western Drive and Echo Street west and north to the west end of Meder Street. WASDY results showed that headlosses were lowered and pressures increased to acceptable levels in the affected area (Table 3-1, Figure 3-2).

The sizes discussed above are approximate but adequate for developing a capital improvement program; sizes should be reevaluated after a more site-specific evaluation by the City using WADSY.

The results of WADSY analyses with and without these improvements was shown in Table 3-1. Costs of the improvements are shown in Table 3-2.

Based on WADSY results for current demands and year 2005 high growth demands, using a straight-line growth in water demand from current to year 2005, the high headlosses and low pressures will not be reached for either Live Oak or the westside until after year 2000. Consequently, these distribution main improvements need not be built until year 2000. In other words, the basic distribution system (except as discussed below) should be satisfactory for the next 10 to 12 years, provided growth occurs as forecasted in Chapter 2.

3.5.2 University System Reservoirs and Pumping Stations

Most of the SCWD's reservoirs and pumping stations are located in areas of minimum growth and would thus continue to be adequately sized for future demands. One exception is the University system, which consists of three reservoirs and pumping stations. UCSC on-campus water demand is forecasted to nearly triple by year 2005 under the high growth scenario (15,000 enrollment -- Table 2-20), so that the current system must be evaluated for future needs.

Analysis of the University system facilities is based on design criteria used in previous studies of the Pasatiempo system by Metcalf & Eddy and in the previous water master plan (Brown and Caldwell, 1963). These criteria are:

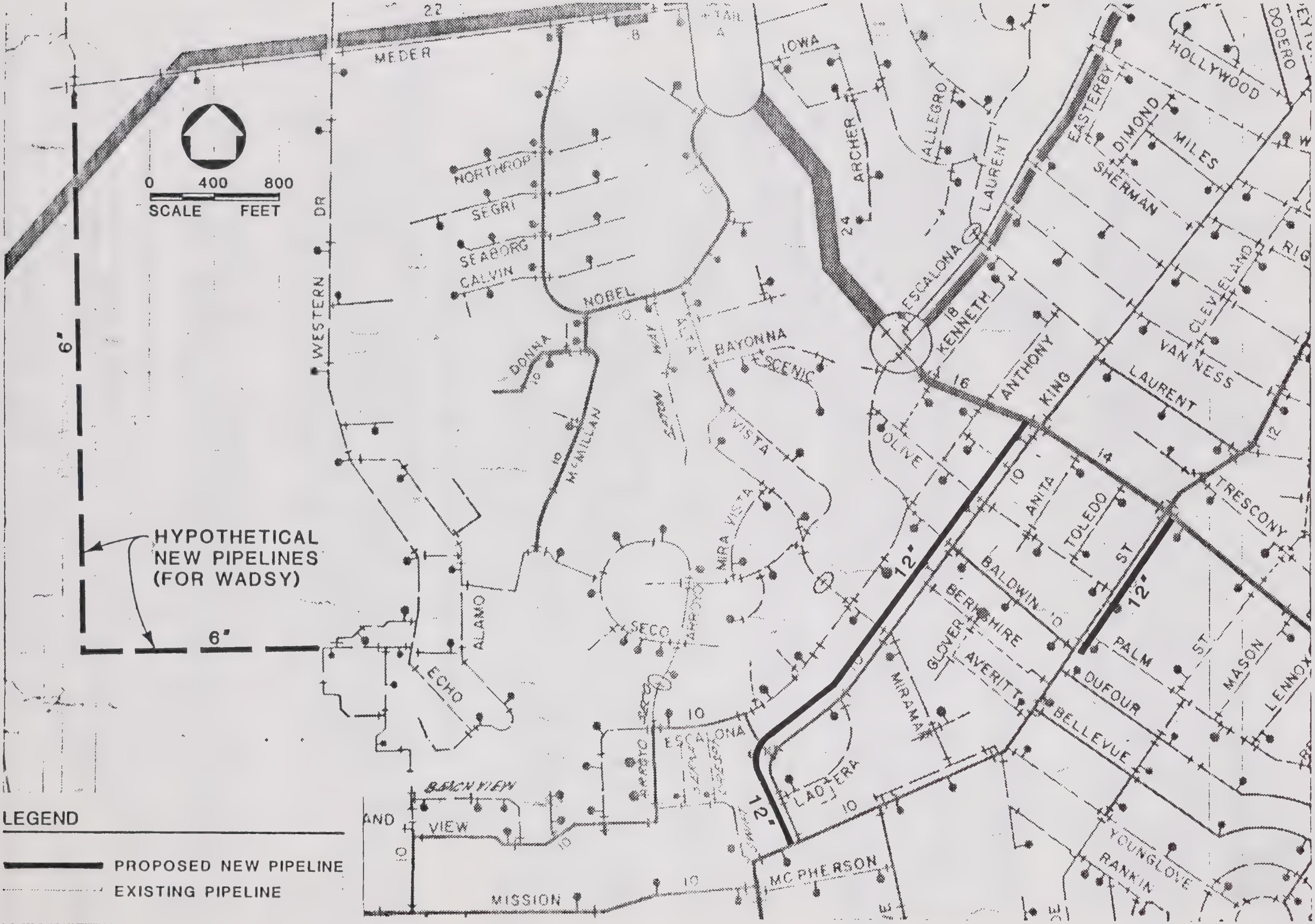


FIGURE 3-2.
PROPOSED NEW WATER MAINS FOR WESTSIDE

Table 3-2
City of Santa Cruz Water Department
Water Master Plan
COSTS OF DISTRIBUTION MAIN IMPROVEMENTS

Location	Length ft	Diameter in. 1/	Unit cost $/ft	Total cost $ 2/	Year required
LIVE OAK AREA					
Water, May to Morrissey	3,900	12	38	148,200	2000
Soquel Ave, 7th to Mattison	4,300	14	46	197,800	2000
Soquel Ave, Mattison to 41st	3,200	12	38	121,600	2000
Mattison, Soquel Ave to Maciel	1,800	8	26	46,800	2000
Delaveaga Reservoir to Mission & Twin Hills	3,200	12	38	121,600	2000
Mission & Twin Hills along Mission and Thurber to Soquel Dr	1,900	10	32	60,800	2000
Soquel Dr, Mission to Thurber	700	12	38	26,600	2000
Soquel Dr, Thurber to Chanticleer	300	10	32	9,600	2000
WESTSIDE					
King, Bay to Escalona	2,600	12	38	98,800	2000
Mission, Bay to Baldwin	1,000	12	38	38,000	2000
Total				869,800	

1/ Diameters are preliminary; final sizes subject to site-specific analyses.

2/ Costs are in 1988 dollars and are for construction only. Techncial services such as design and construction administration are not included.

(1) Reservoir sizing

a. Fireflow requirements. This figure was computed in the Long Range Development Plan (LRDP) based on National Fire Protection Association standards.

b. Peak hourly reserve equal to 23% of peak daily demand.

c. Emergency reserve (pump malfunction) equal to one third of peak daily demand.

(2) Pump capacities based on maximum daily flows.

The required capacities were based on distribution of demand among the pumping stations as listed in the UCSC LRDP. The demand for Pumping Station #2 also includes the new westside greenbelt area development mentioned above. The existing and new capacities are as shown in Tables 3-3 and 3-4. A new 0.4 million gallon reservoir must be constructed and the capacity of each of the pumping stations must be expanded.

The scheduling of these improvements is based on a straight-line growth from current campus water use (base year 1986 as set forth in the LRDP) to forecasted water use at 15,000 enrollment by year 2005. The required storage of Reservoir #5 will increase from 1.5 to 2.2 million gallons. Since the existing capacity is 2.0 million gallons, a new reservoir will need to be built by about year 2000. Pumping station #4 is currently below required capacity and should have highest priority for expansion. The capacities of stations #2 and #6 are currently greater than required pumping needs, but will reach their limits before 1995 (Table 3-4). The expansion should be scheduled between 1990 and 1995.

A summary of recommended improvements to the University system and their costs is shown in Table 3-5.

Table 3-3
City of Santa Cruz Water Department
Water Master Plan

REQUIRED CAPACITIES OF RESERVOIRS FOR UNIVERSITY SYSTEM

		Base year (1986)	15,000 enrollment (2005)
TANK 5			
Average daily pressure zone use, gpd 1/		342,888	930,508
Peak daily pressure zone use, gpd 2/		685,776	1,861,016
Required storage, gal			
Peak hour	23% of peak	157,728	428,034
Emergency	33% of peak	228,592	620,339
Fire flow 3/		1,121,280	1,121,280
Total		1,507,600	2,169,652
Actual capacity, gal		2,000,000	2,000,000
TANK 4			
Average daily pressure zone use, gpd 1/		105,246	210,374
Peak daily pressure zone use, gpd 2/		210,492	420,748
Required storage, gal 4/			
Peak hour	23% of peak	48,413	96,772
Emergency	33% of peak	70,164	140,249
Total		118,577	237,021
Actual capacity, gal		400,000	400,000
NEW TANK			
Average daily pressure zone use, gpd 1/		N/A	132,912
Peak daily pressure zone use, gpd 2/		N/A	265,824
Required storage, gal			
Peak hour	23% of peak	N/A	61,140
Emergency	33% of peak	N/A	88,608
From Tank 5		N/A	169,652
Total		N/A	319,400

1/ Based on LDRP and Table 2-20.
2/ Assuming a peak factor of 2.0.
3/ Based on LDRP.
4/ Based on LDRP, fire flows can be directed from Tank 5.

Table 3-4
City of Santa Cruz Water Department
Water Master Plan

REQUIRED CAPACITIES OF PUMPING STATIONS FOR UNIVERSITY SYSTEM

	Base year (1986)	15,000 enrollment (2005)	
PUMP 2			
Average daily use, gpd 1/			
On Campus	448,134	1,273,877	
Off Campus	49,234	112,234	2/
Total	497,368	1,386,111	
Peak daily use, gpd 3/	994,736	2,772,222	
Required pump capacity, gpm	691	1,925	
Actual pump capacity, gpm	1,275	1,275	
PUMP 4			
Average daily demand on campus, gpd 1/	448,134	1,273,877	
Peak daily use, gpd 3/	896,268	2,547,754	
Required pump capacity, gpm	622	1,769	
Actual pump capacity, gpm	567	567	
PUMP 6			
Average daily demand on campus, gpd 1/	342,888	1,063,421	
Peak daily use, gpd 3/	685,776	2,126,842	
Required pump capacity, gpm	476	1,477	
Actual pump capacity, gpm	825	825	
NEW PUMP 4/			
Average daily demand on campus, gpd 1/	N/A	132,912	
Peak daily use, gpd 3/	N/A	265,824	
Required pump capacity, gpm	N/A	185	

1/ Based on LDRP and Table 2-20.
2/ Also includes westside development (Tables 2-6, 2-7, 2-16).
3/ Assuming a peak factor of 2.0.
4/ To serve new reservoir (Table 3-3).

Table 3-5
City of Santa Cruz Water Department
Water Master Plan

SUMMARY OF IMPROVEMENTS
UNIVERSITY SYSTEM

Improvement	Estimated cost, $ 1/	Year required
New 0.4 mil gal University reservoir	600,000	2000
New 200 gpm University pumping station	50,000	2000
Expand/upgrade University pumping station #2	25,000	1992
Expand/upgrade University pumping station #4	25,000	Immediate
Expand/upgrade University pumping station #6	25,000	1995

1/ Costs are 1988 dollars and are for construction only. Technical services such as design and construction management are not included. Reservoir estimate includes allowance for site work, access road, piping, valves, etc.

CHAPTER 4

EXISTING WATER SUPPLY SYSTEM

4.1 GENERAL

A map and hydraulic profile of the SCWD's existing water supply system is shown in Figures 4-1 and 4-2, respectively. The SCWD supply system is comprised of four main production systems -- (1) the North Coast, (2) the San Lorenzo River (two independent diversions), (3) Loch Lomond Reservoir on Newell Creek, and (4) the Beltz Wells. A thorough understanding of the system's facilities and operations is essential to developing improvements to optimize the use of the existing sources and facilities. Therefore, a comprehensive review and analysis of the SCWD water supply system was undertaken. The findings of this work are described in the following sections of this chapter. The following aspects were investigated:

(1) physical characteristics of all facilities;
(2) water rights limitations;
(3) hydraulic capacities of each facility;
(4) unit production costs of each source; and
(5) current operational procedures.

4.2 EXISTING FACILITIES

An inventory of the existing water supply facilities in the SCWD system was compiled and is presented in Table 4-1. These facilities include diversions, wells, transmission pipelines, booster pumps, and water treatment plants (WTPs). Distribution mains, pumping stations and storage reservoirs "downstream" of WTPs are considered to be part of the water distribution system and are covered in Chapter 3. The main facilities of the SCWD supply system are described in the following subsections.

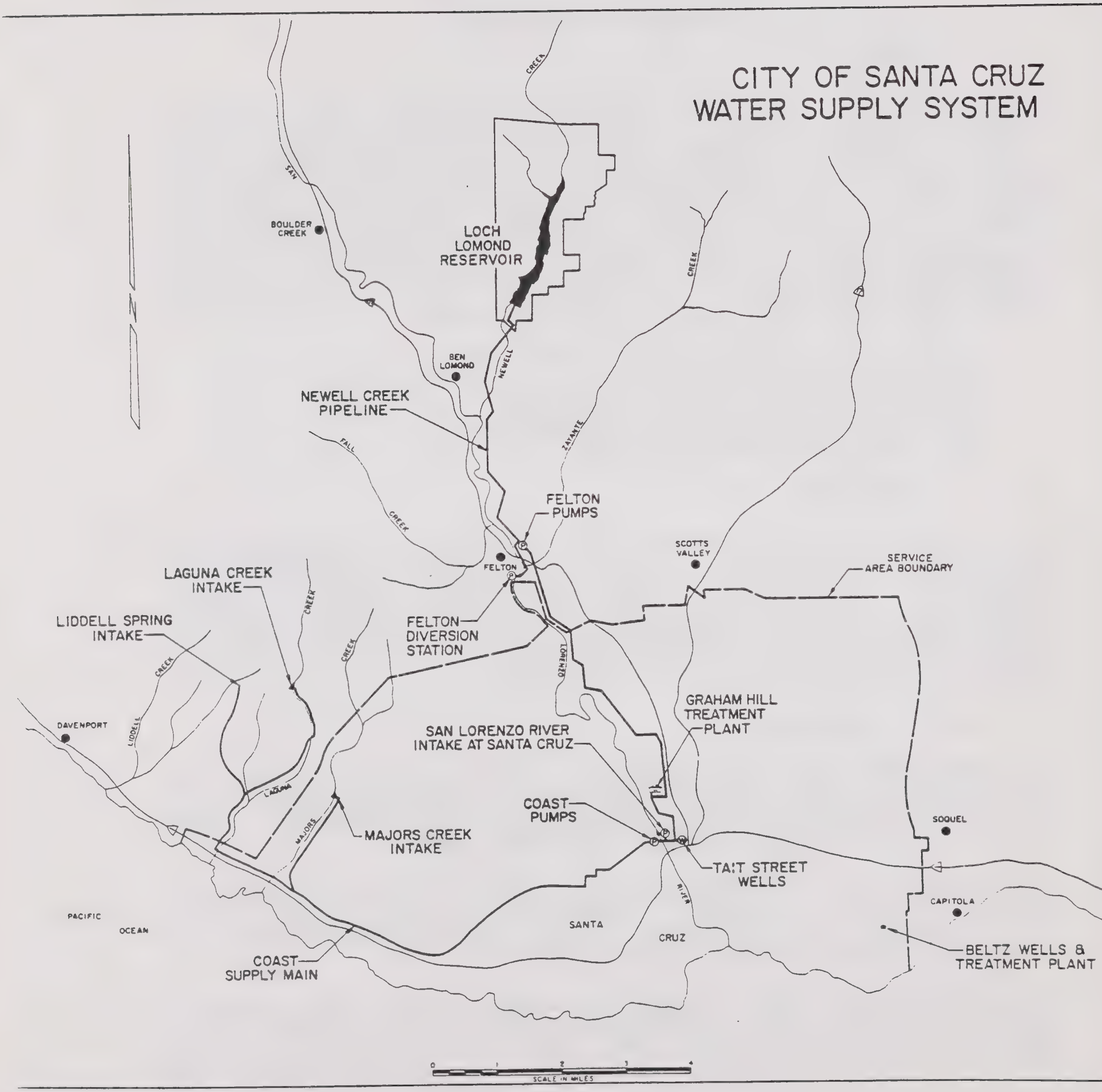
4.2.1 North Coast

The North Coast water supply system consists of surface diversions from three coastal streams and one natural spring located approximately six to eight miles northwest of downtown Santa Cruz. These sources are Liddell Spring, Laguna Creek, Reggiardo Creek, and Majors Creek.

Liddell Spring is a natural spring used for water supply and was developed in 1913. The spring "diversion" is located at elevation 584 feet. Water from the spring is directed through a 10-inch steel pipeline into the Coast Pipeline for transmission to the SCWD service area.

Flows from Reggiardo Creek are captured at a diversion dam located at elevation 630 feet. Diversions from Reggiardo Creek are diverted through about 850 feet of pipeline to Laguna Creek. Flows from Laguna Creek and diversions from Reggiardo Creek are captured at a concrete and limestone dam

FIGURE 4-1



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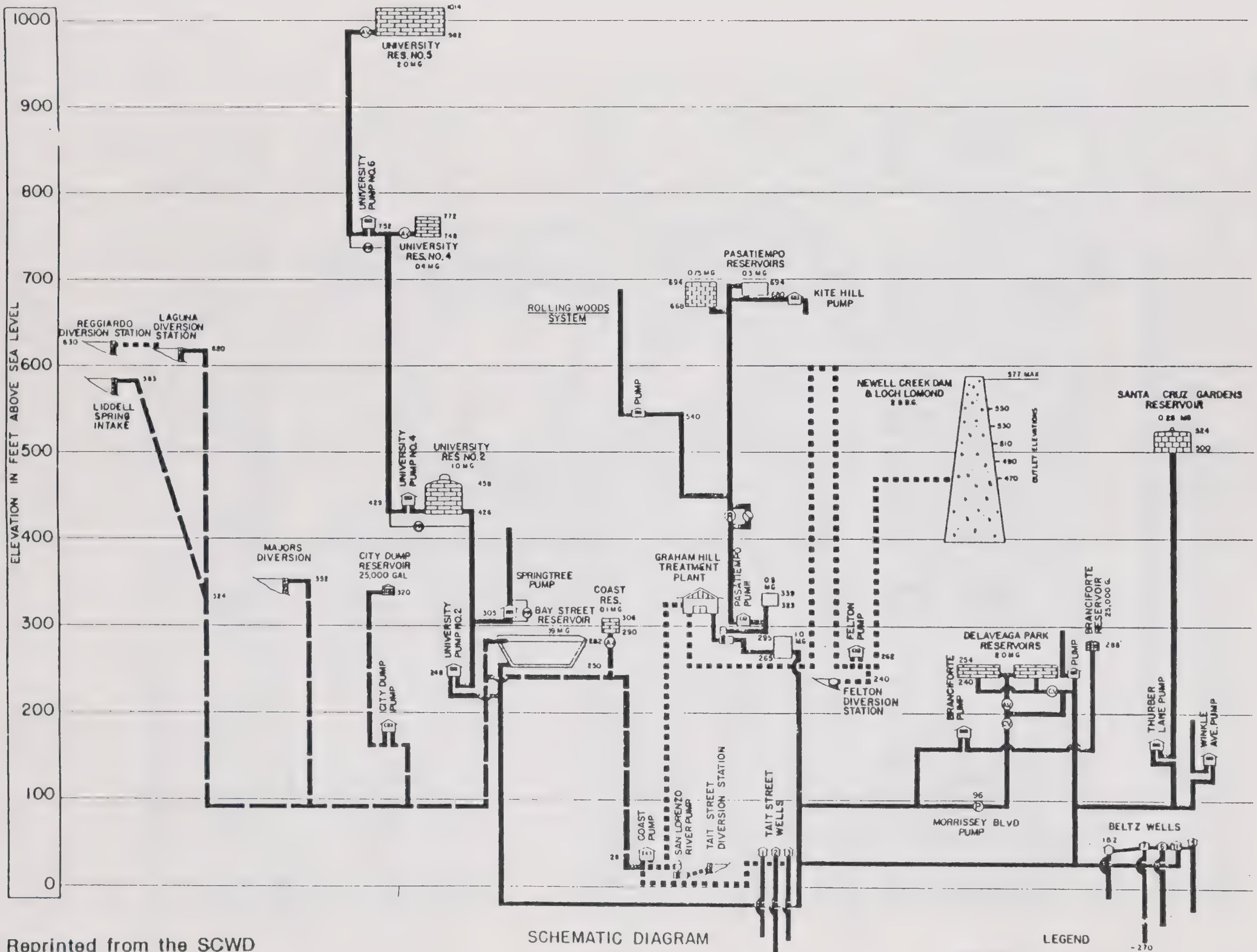

Reprinted from the SCWD Annual Report, 1985-86.

SCHEMATIC DIAGRAM

OF

WATER SYSTEM

CITY OF SANTA CRUZ, CALIFORNIA

LEGEND

RAW WATER
CHLORINATED WATER
TREATED WATER

Revised 5-10-82
1373-D

FIGURE 4-2

Table 4-1

City of Santa Cruz Water Department
Water Master Plan

INVENTORY OF EXISTING PRODUCTION FACILITIES

FACILITY	YEAR	TYPE	SIZE	ELEVATION
DIVERSIONS				
North Coast				
Liddell Spring	1913	Spring	---	584
Reggiardo Creek	1890	Concrete Dam	---	630
Laguna Creek	1890	Concrete Dam	---	623
Majors Creek	1916	Concrete Dam	---	352
San Lorenzo River				
Tait Street	1928	Concrete Dam	---	28
Felton Diversion	1975	Inflatable Dam	---	240
Loch Lomond Reservoir	1960	Earthfill Dam	2810 MG	400-590
WELLS				
Tait Street	1928	Four	2 MGD	85-104
Beltz	1967	Four	2 MGD	60
PUMPING STATIONS				
Coast	N/A	---	2 - 50 HP	28
		---	1 - 200 HP	
Tait Street Diversion	1961	---	3 - 250 HP	28
Felton Diversion	1975	---	2 - 200 HP	240
		---	1 - 450 HP	
Felton Booster	1960	---	3 - 60 HP	262
		---	2 - 100 HP	
		---	1 - 125 HP	
TRANSMISSION PIPELINES				
North Coast	1912,1961	10" Steel	7,670 FT	28-630
	1978	10" Asbestos Cement	3,775 FT	
	1965	12" Cast Iron	250 FT	
	1978	12" Asbestos Cement	250 FT	
	1912-1978	14" Steel	21,930 FT	
	1959	14" CL&C	6,660 FT	
	1953,1978	16" Steel	14,345 FT	
	1931,1965	20" Cast Iron	8,260 FT	
	1959	21" CL&C	1,310 FT	
	1924,1953	22" Steel	26,080 FT	
	N/A	24" Unknown type	5,425 FT	
Loch Lomond Reservoir	1961	18"	870 FT	240-377
	1961	20"	3,800 FT	
	1961	22"	34,200 FT	
	1961	27"	8,800 FT	
	1961	36"	1,150 FT	
TREATMENT PLANTS				
Beltz	1967	Iron & Manganese Removal	2 MGD	182
Graham Hill	1959	Complete Treatment	24 MGD	319

TAB4-A.WK1/F796-03-JMK-7

located at elevation 623 feet on Laguna Creek. The original dam constructed in 1890 is still in use today. These diversions are sent through 12,400 feet of 14-inch steel pipeline to the junction with the transmission pipeline from Liddell Spring (the Laguna-Liddell "Y").

Flow from Majors Creek is diverted from a concrete dam located at elevation 352 feet. This dam also dates back to the late 1800's when it was constructed by a private water company. Diversions from Majors Creek are conveyed through 11,300 feet of pipeline varying between 10 and 16 inches in diameter before joining the main Coast Pipeline along Highway 1. Because the Majors Creek diversion is located at a much lower elevation than the other North Coast sources, a check valve is located at the lower end of the Majors Creek transmission pipeline to prevent backflow from the other sources. Thus, use of the Majors Creek Diversion is presently limited by the hydraulic loading from the other North Coast sources.

Water from the North Coast diversions flows by gravity to the northwest portion of the SCWD system via the Coast Pipeline, which varies from 16 inches in diameter between the Laguna-Liddell "Y" and Majors Creek up to 24 inches in diameter near Bay Street Reservoir. Several sections of this pipeline have been replaced over the years due to deterioration and excessive head losses. According to SCWD staff, the Coast Pipeline has a minimum design pressure rating of 150 pounds per square inch (PSI).

Water from the Coast Pipeline is boosted at the Coast Pump Station to the Graham Hill Water Treatment Plant (GHWTP) for complete treatment. In the past, North Coast diversions have also been made directly into the SCWD distribution system at Bay Street Reservoir during certain periods, but this practice has been discontinued due to health concerns and incoming drinking water regulations.

4.2.2 San Lorenzo River - Tait Street Diversion

San Lorenzo River (SLR) flows are diverted for use at the Tait Street Diversion just north of Highway 1. Water is diverted at a concrete check dam into to a screened intake sump where three vertical turbine pumps are used to pump the water to GHWTP. These pumps are located in the same building as the pumps for the North Coast diversions. Due to severe flood damage potential, the Tait Street surface diversion intake was recently relocated to the west side of the river. This relocation is expected to withstand major flood events with only minor damage.

The Tait Street Diversion also includes three groundwater wells located on the east side of the river, ranging in depth from 85 to 104 feet. The wells are extremely old and are in need of rehabilitation. Based on prior study, the Tait wells are believed to be at least partially hydraulically connected to the river. Thus, withdrawals from the wells may decrease the flows in the river and little long-term storage is obtained from the aquifer.

Water produced by the Tait wells is delivered to a separate sump on the west side of the river through a 16-inch diameter pipeline crossing under the river. The groundwater is then pumped into a common 24-inch diameter transmission pipeline used to convey water from both the North Coast and SLR sources to GHWTP, approximately one mile north of the SLR Tait Street Diversion.

4.2.3 San Lorenzo River - Felton Diversion

The Felton Diversion is located on the San Lorenzo River approximately five river miles north of the Tait Street Diversion just downstream of the Zayante Creek confluence. The diversion structure consists of an inflatable rubber dam to divert flows into a screened intake sump. Flows are then pumped through the Felton Booster Station and into Loch Lomond Reservoir for storage via the Newell Creek Pipeline (see Section 4.2.4). The desired diversion rate is regulated by using different combinations of the three pumps at the Felton Diversion and the six pumps at the Felton Booster Station.

4.2.4 Newell Creek (Loch Lomond Reservoir)

The Newell Creek supply system includes Loch Lomond Reservoir, the Newell Creek Pipeline, and Felton Booster Station. Loch Lomond Reservoir was created by the construction of Newell Creek Dam, located about ten miles north of Santa Cruz near the town of Ben Lomond. The reservoir was constructed in 1960 to store up to 2810 MG (8500 AF) for use by SCWD and the San Lorenzo Valley County Water District (SLVCWD). Loch Lomond is the only major reservoir in the SLR watershed.

Newell Creek Dam is an earthfill dam, 190 feet high and 750 long at the crest. The spillway crest is at elevation 577 feet. Releases from the reservoir are made through outlet works on the upstream face of the dam. The lowest outlet is at elevation 470 feet. At maximum capacity of 2810 MG, the reservoir surface covers an area of 180 acres.

Loch Lomond is relatively undersized for its watershed. The average annual inflow is about 1825 MG/YR. Therefore, because only 2810 MG of storage capacity is available, the reservoir frequently spills. In fact, except for very dry years, the reservoir is normally completely full by late Spring.

Water released from Loch Lomond Reservoir for use by SCWD is conveyed to GHWTP through the Newell Creek Pipeline, a steel concrete cylinder pipeline which varies from 18 to 27 inches in diameter. The water flows by gravity from the reservoir to the Felton Booster Station, approximately 4.3 miles downstream of the dam. The water is then pumped at Felton Booster Station to clear a ridge in Henry Cowell State Park at an elevation of about 580 feet. In order to meet fluctuating head-flow conditions, six pumps and alternative valving configurations are available at the Felton Booster Station.

4.2.5 Beltz Wells

The Beltz well system consists of six groundwater wells located in the southeastern portion of the SCWD service area. The wells were incorporated into the SCWD system in 1967 after the City purchased the system from the Beltz Water Company. Water pumped from the wells is treated for iron and manganese removal at the Beltz WTP and is delivered directly into the distribution system.

4.3 WATER RIGHTS

All available water rights documents for the SCWD sources were collected and reviewed. The water rights currently held by SCWD are summarized in Table 4-2. Limitations caused by these rights, which have a profound influence on the yield of the water supply system, were included in the analysis of the system's operation. The water rights for each source are discussed in the following paragraphs.

North Coast - The SCWD's water rights for the North Coast sources were obtained through the purchase of riparian water rights of downstream landowners. When Laguna Creek was developed as a source in 1890 and Liddell Spring was developed in 1913, the City of Santa Cruz purchased the riparian rights of all downstream landowners and agreed to provide water service (see Chapter 6). Rights on Majors Creek were acquired through purchase of a private water company in 1916, which had earlier purchased the riparian rights of downstream users. The priority date for this water right was established in 1881. Rights for Reggiardo Creek were acquired with Laguna Creek, and have a priority date of 1912.

Since the water from the North Coast sources has been used continuously by SCWD (i.e., with no period of non-use exceeding five years), these rights are established as appropriative rights with pre-1914 status. Prior to 1914, the state had essentially no formal regulation of water rights. Only a minimal amount of posting was necessary and then the water was simply put to use. Therefore, due to their pre-1914 status, there are no specified limits on diversion rates or quantities for the North Coast sources.

San Lorenzo River (Tait Street Diversion) - Water rights for the Tait Street Diversion on the SLR consist of two licenses (nos. 1553 and 7200) for appropriative rights to a maximum combined diversion rate of 12.2 CFS. The maximum diversion rate applies to the combined flows from the Tait Street Diversion and the Tait Street Wells. Diversions under these water rights can be made year-round and no annual limit is specified in the licenses. Also, no downstream release requirements are included in these water rights.

Table 4-2

City of Santa Cruz Water Department
Water Master Plan

SUMMARY OF WATER RIGHTS

SOURCE	PERIOD	MAXIMUM DIVERSION RATE	FISH FLOW REQUIREMENT	ANNUAL DIVERSION LIMIT
NORTH COAST 1/	Year-round	No limit	None	None
SAN LORENZO RIVER				
Tait Street Diversion and Wells	Year-round	12.2 CFS	None	None
Felton Diversion to Loch Lomond Reservoir	September	7.8 CFS	10 CFS	977 MG
	October	20.0 CFS	25 CFS	
	November-May	20.0 CFS	20 CFS	
	June-August	--- CFS	--- CFS	
LOCH LOMOND RESERVOIR ON NEWELL CREEK				
Collection	September-June	No limit	---	1,825 MG
Withdrawal	Year-round	---	1 CFS	1,042 MG

1/ Water rights for City of Santa Cruz North Coast Sources are pre-1914 rights with all downstream rights purchased by City; therefore, City may divert up to the full natural flow of each stream.

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San Lorenzo River (Felton Diversion) - SCWD also has appropriative water rights to divert San Lorenzo River flows from the Felton Diversion into Loch Lomond Reservoir. The Felton Diversion water rights are formed by two permits (nos. 16123 and 16601). As indicated in Table 4-2, diversion is limited to maximum rates of 7.8 CFS in September and 20 CFS from October 1 to June 1 and cannot exceed a total 977 MG (3000 AF) per year. Minimum bypass flow requirements are also required for the preservation of fish and wildlife. These flow requirements (if adequate natural flow is available) are 10 CFS for September, 25 CFS for October, and 20 CFS for the period from November 1 through May 31.

Newell Creek (Loch Lomond Reservoir) - Water rights for Newell Creek at Loch Lomond Reservoir allow for a maximum of 1,825 MG per year to be collected from September 1 to July 1. The maximum allowable storage at Loch Lomond is 2,810 MG, the current capacity of the reservoir. Withdrawals from the reservoir for SCWD can be made year-round but are limited to 1,042 MG per year. Storage at the reservoir is shared with SLVCWD, which is entitled to 12.5 percent or 102 MG of the safe annual yield. Also, a fish flow release of 1 CFS must be made year-round.

4.4 HYDRAULIC CAPACITIES

4.4.1 General

In estimating the yield of the SCWD water supply system with either current or additional facilities, accurate determinations of the hydraulic capacities of the diversion systems were needed. These capacities, along with other constraints such as water rights limitations, are imposed on the estimated streamflows to determine the quantities of water which can actually be diverted for use from each source. Therefore, a hydraulic network computer model was developed to determine the hydraulic capacities of the water supply system under a range of alternative conditions.

The results of the work described in this section were used to determine the hydraulic capacities of each SCWD diversion facility for use in hydrologic and operations studies of the entire supply system. The development and verification steps used to create the model for the SCWD water supply system and the subsequent results are presented in the following sections. More detailed information on this model is given in Appendix E bound separately.

4.4.2 Development of Hydraulic Network Model

The University of Kentucky's Pipe Network Analysis Program, developed by Dr. Donald J. Wood, was selected for use in this study to model the hydraulics of the SCWD water supply system. This program is widely used in the water supply industry and is generally recognized as the state-of-the-art method for modelling flows and pressures in water distribution systems. Pipelines, reservoirs, pumps, valves, wells, and other facilities may be included in a model of water distribution systems.

Input to the hydraulic network model included the pipeline lengths and diameters, estimated pipe roughness coefficients, hydraulic grade line elevations for sources and reservoirs, ground elevations, and pump performance curves. These data were obtained from maps of the SCWD system, pump tests by Pacific Gas & Electric (PG&E), various technical reports, numerous discussions with staff, and miscellaneous tables and charts found in SCWD's files.

Once the hydraulic network model was formulated and "debugged", the computed flows and pressures were compared against measured data and appropriate adjustments in the input parameters were then made. This verification process in described in the following subsection.

4.4.3 Verification and Results of Hydraulic Network Model

Comparisons of the flows and pressures computed by the network model with corresponding field measurements were used to verify the geometry (i.e., pipeline sizes and system configuration) of the system and to adjust the estimated input parameters such as pipeline friction coefficients and pump curves. This refinement process is critical to producing a reliable model which, in turn, provides estimates for important hydraulic constraints used in determination of the supply system's yield for alternative conditions and facilities.

The verification process used in this study was based on the use of the following data:

(1) Recent PG&E pump test reports for all pump stations in the water supply system, including a variety of pumping arrangements at each station;

These pump tests, most of which were conducted during 1987, report the flow and total dynamic head at the pumping unit. Because the total head at the pump is dependent on pipe friction losses and other hydraulic conditions throughout the system, these tests can be used to refine both pump performance curves and pipe friction coefficients.

(2) Hydraulic tests performed by The Pitometer Associates in 1977 on the Newell Creek Pipeline between Loch Lomond Reservoir and Felton Booster Station;

These tests indicated that the Newell Creek Pipeline had a Hazen Williams friction coefficient of 127.

(3) Measured water production data for the North Coast system, which gives an indication of the maximum capacity of the various

sources. (The computed capacity should be equal to or larger than the maximum historical production.); and

(4) Discussions with SCWD operating personnel.

Once the model was verified and calibrated within acceptable accuracy, the hydraulic capacities of each existing diversion were determined. In addition, the impact of future improvements such as pump stations or parallel pipelines were also examined.

The results of the modelling effort which were used in subsequent hydrologic and operations studies to determine the system's yield, are summarized in the following paragraphs:

North Coast - The model indicated that Liddell Spring, Laguna Creek, and Majors Creek are capable of supplying 2.6, 7.0, and 4.4 CFS, respectively, when operating separately. When all sources are operated simultaneously and more than adequate runoff is available, the capacities for Liddell Spring and Laguna Creek will decrease slightly and the Majors Creek capacity will decrease significantly due to the hydraulic impacts of the combined flows. The maximum capacity of the North Coast system will actually vary between 9.1 and 9.4 CFS depending on the status of the SLR-Tait Street pumps. If the SLR pumps are operating at capacity, the increased head losses in the pipeline between the Coast Pump Station and GHWTP will result in the lower capacity for North Coast diversions. Further explanation on the detailed interaction between the North Coast sources is provided in Appendix E.

San Lorenzo River (Tait Street Diversion) - The San Lorenzo River surface diversion pumps are estimated to deliver about 11.2 CFS when operated separately (i.e., without the Tait wells and Coast Pump Station). The wells can deliver up to 1.9 CFS when operated alone. Operated together, the capacity of the surface and well pumps is estimated at 12.9 CFS when the Coast Pump Station is not operating and about 10.9 CFS when the Coast Pump Station is operating at full capacity. It should be noted that the Coast Pump Station will only run at full capacity during high runoff months.

San Lorenzo River (Felton Diversion) - Although adequate pumping capacity is available for diversions up to about 14 CFS, production from Felton Diversion was found to be limited by the internal design pressure of the pipeline between the Felton Booster Station and Loch Lomond Reservoir. This pipeline was originally designed to convey water from Loch Lomond Reservoir to Felton Booster Station. At the critical segment on the reservoir side of Felton Booster, the maximum pressure (under static conditions) would be about 135 PSI (577 feet at reservoir less ground elevation at Felton Booster of about 260 feet). Hence, the pipeline was designed for a maximum operating pressure of 150 PSI at this point. Although a factor of safety is typically included for surge protection, operation at pressures well above the design pressure is not prudent.

Based on the design pressure of the pipeline, use of the model indicated that the maximum capacity of Felton Diversion would be restricted to about 8.6 CFS when Loch Lomond Reservoir is nearly full in order to maintain an operating pressure of 150 PSI. Slightly higher diversion rates could be used if the reservoir is considerably lower than its maximum elevation. Based on a review of daily records, diversions well above 9 CFS have occurred in the past with no apparent adverse effects. However, sampling and testing of the low-pressure pipe segment should be done before operating above 10 CFS in the future.

Newell Creek (Felton Booster Station) - With all six pumps operating, Felton Booster Station is able to pump a maximum of between 11.2 and 14.4 CFS from Loch Lomond Reservoir depending on the water level at the reservoir. With only the three large pumps (1,3,5) operating, the capacity is between 7.8 and 11.2 CFS depending on the reservoir level.

Beltz Wells - The capacity of the Beltz water system is reported to be 2 MGD (3.1 CFS). Because operations at Beltz are independent of other supply facilities and the reported capacity is reliable, this value has been used in subsequent analyses.

4.5 UNIT PRODUCTION COSTS

The cost of operating each of the sources available to the SCWD can be important in evaluating alternative procedures for operating the water supply system. Because of the potential importance of pumping costs in determining optimal system operations, the unit variable cost of production for each of the SCWD sources was determined. Production costs which vary with the amount of water supplied (i.e., variable costs) are limited to energy costs for pumping and chemical costs for treatment.

Energy records, PG&E pump tests, and water production records for 1982 to 1986 were reviewed to determine the variable unit pumping costs for each source. Additional information on the development of unit costs for pumping of the source is given in Appendix E. In addition to pumping costs at the sources, the unit cost of production also includes the variable cost of treating the water supply. Review of the expense records from SCWD annual reports and discussions with SCWD staff indicated that the variable cost for full treatment of the surface supplies at GHWTP is about $30/MG for treatment only. This value includes energy and chemical costs at GHWTP which vary with the quantity of water treated. The primary variable cost for treatment at the Beltz WTP is the chemical cost for chlorination, about $5/MG.

The pumping costs were combined with treatment costs to yield the unit variable cost of producing water from each source. These costs, shown in Table 4-3, were applied to the diversions from each source in the operations studies to determine the economic impacts of alternative facilities and procedures. In reviewing Table 4-3, it should be noted that no total cost

Table 4-3

City of Santa Cruz Water Department
Water Master Plan

SUPPLY PRODUCTION COSTS
(1988 Dollars)

Source	Average Variable Unit Cost of Pumping ($/MG) 1/	Total Variable Unit Cost ($/MG) 8/
North Coast	25 2/	55
San Lorenzo River		
Tait St. Diversion	115 3/	145
Tait Street Wells	200 4/	230
Felton Diversion	170 5/	---
Felton Booster	30 - 100 6/	60 - 130
Beltz Wells	200 7/	205 4/

1/ Estimated from review of PG&E pump test data, energy rate schedules, City Finance Department's energy bill summaries, and SCWD monthly reports.
2/ For flows through the Coast Pump Station.
3/ With all three surface diversion pumps operating.
4/ Average cost for wells plus booster pump.
5/ Pumping from Felton Diversion into Loch Lomond Reservoir only; additional cost of "Felton Booster" also incurred upon use.
6/ Pumping from Loch Lomond Reservoir to Graham Hill WTP; pumping cost varies due to significant changes in head loss for different flow rates and fluctuations in reservoir levels; high end of range represents operation with all six existing pumps.
7/ Includes pumping at well and booster station.
8/ Includes $30/MG for full treatment at Graham Hill WTP and $5/MG for chlorination at Beltz WTP.

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is shown for Felton Diversion since production from this source includes only the cost of pumping from the San Lorenzo River to Loch Lomond Reservoir; the total variable cost for Felton Booster is later incurred when the water is delivered for use.

4.6 CURRENT OPERATIONS

Although no formal operating "rules" are used at this time, the SCWD uses numerous procedures and informal rules to operate the water supply system. In general, the SCWD supply system is currently operated to use the better quality and less expensive sources first while maintaining a reasonable reserve in Loch Lomond Reservoir. Current operations are described in this section, primarily to provide background information for the detailed operating procedures described in Chapter 8.

Due to excellent water quality and the lowest production cost, SCWD uses the North Coast sources to the greatest extent possible. North Coast water is used year-round, except during periods of high surface runoff during and immediately after rainfall events when turbidity is high. As explained in Chapter 6, SCWD must "turn off" the North Coast diversions, whenever turbidity levels rise, in order to provide acceptable drinking water quality for domestic services which are served directly from the Coast Pipeline. During the ten-year period from 1976-86, annual production from the North Coast diversions averaged 1030 MG.

If diversions from the North Coast are insufficient to meet demands, either the SLR-Tait Street diversion or the Newell Creek system is operated. However, during heavy rainfall, both the North Coast sources and the SLR-Tait Street diversion become inoperable due to excessive turbidity. Although the SLR water is not delivered directly to customers, potential complications in treating water with high turbidity make diversions from the river undesirable. In such instances, withdrawals from Loch Lomond Reservoir are made to meet the entire demand. Although Bay Street Reservoir could be used to meet a portion of the demand during rainy periods, SCWD operating personnel prefer to reserve the storage at Bay Street Reservoir for possible emergencies.

During the ten year period from 1976-86, annual production from the SLR-Tait Street surface diversion averaged 1280 MG while the Newell Creek system produced an average of about 970 MG. Although water is generally available year-round, the majority of water production from the SLR-Tait Street surface diversion occurs during the high demand period from June to October. Monthly withdrawals from Loch Lomond Reservoir tend to fluctuate greatly within a given year but are relatively constant on a long-term average basis. In other words, Loch Lomond Reservoir is used on a year-round basis to reduce production costs and/or to augment surface diversions. Production from the Newell Creek system tends to be highest in the month of March, when the reservoir is often spilling. In the fall months, reservoir withdrawals are about 25 percent below the annual average.

Due to a number of operational problems, the Beltz WTP has rarely operated at or near its design capacity. From 1976 to 1986, water production from the Beltz system averaged about 115 MG per year or about 10 MG per month. The Beltz system is now reportedly capable of operating at full capacity for extended periods if necessary. However, due to the high production cost and less desirable water quality, the Beltz source is not utilized to full capacity. Additionally, it must be noted that the system has not been stressed enough to adequately predict its reliability when operated continually.

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Chapter 5

WATER QUALITY AND TREATMENT

5.1 INTRODUCTION

The purposes of this chapter are to (1) review the existing water quality data of the raw water sources and treated water, (2) review the recent changes in water quality regulations and summarize their probable impact on the City's existing water treatment operations, and (3) develop an improvement plan for the water treatment facilities to ensure compliance with the water quality regulations. A detailed review of the existing and pending water quality regulations is provided in Appendix D.

5.2 WATER QUALITY

5.2.1 Background

Santa Cruz obtains its raw water from both groundwater and surface water sources. These waters are treated at either the Graham Hill Water Treatment Plant (GHWTP) or the Beltz WTP.

Background information on water quality was obtained from the Santa Cruz Water Department (SCWD). These data consisted of information obtained primarily from three sources:

1. Routine monitoring of the sources and distribution performed by the SCWD (1976 through mid-1988)
2. Annual chemical analyses (1978 through 1986).
3. Interviews with plant personnel.

In addition, the following reports and studies were made available:

1. North-Central Santa Cruz County Water Master Plan, Task 2. Prepared by HEA, a Division of J.H. Kleinfelder & Associates. November 1983; revised June 1985.
2. Final Report, Graham Hill Water Treatment Plant Modernization. John Carollo Engineers. May 1984.
3. Water Quality Standards and Treatment Study, CH2M-Hill, March 1985.

5.2.2 Existing Raw Water Quality

Surface waters available to the SCWD are primarily from three sources:

1. Loch Lomond - a reservoir on Newell Creek
2. San Lorenzo River via the Tait Street and Felton diversions
3. The coastal sources consisting of diversions on Majors Creek, Laguna Creek, and Liddell Spring

Two groundwater sources are also available:

1. Tait Street wells
2. Beltz wells

After a review of the existing data and interview with plant personnel, quality characteristics of each of these sources have been developed. These characteristics were divided into three general categories of physical, chemical, and biological components, and reviewed against the drinking water standards (Section 5.3). A comparison was made and it was determined that treatment is needed for turbidity, color and odor, iron and manganese, and bacteriological indicators.

<u>San Lorenzo River</u>.

<u>Physical Characteristics</u>. San Lorenzo River water is of good quality. Turbidity levels are normally low, less than 5 NTU (nephelmometric turbidity units), but are extremely sensitive to high flow due to runoff conditions, with reported levels of over 300 NTU. Discussions with plant personnel indicate that the turbidity level increases very rapidly during these high flow events and returns to normal within a few days, which is borne out by the data.

Other physical characteristics of the San Lorenzo River that, on occasion, have exceeded the drinking water standards are corrosivity, color, and odor. These are secondary standards, which are further discussed in Section 5.3.

<u>Chemical Characteristics</u>. Higher concentrations than secondary standards for iron and manganese have been reported for the San Lorenzo River. All other recorded chemical characteristics of the river are below the Maximum Contaminant Level (MCL) set by the water quality standards. As pointed out in the John Carollo report (Section 5.2.1), the endrin concentration for 1978 was reported as less than 0.005 mg/L, which is above the primary standard, but this reported value is most likely due to the analysis technique and not an actual detection of endrin.

Biological Characteristics. As would be expected from an uncontrolled surface water supply, positive bacteriological readings are present. The presence of bacteria in the coliform group is used as an indication that microorganisms related to human and/or animal diseases may be present. The higher the Most Probable Number (MPN) of the indicator organisms, the higher the probability that disease organisms may be present. With a complete treatment program, such as provided at GHWTP, these concentrations should be of no major concern.

Loch Lomond.

As in the case of the San Lorenzo River, the quality of Loch Lomond is generally good for a surface water supply. Because it is an impoundment reservoir, it exhibits the normal characteristics that would be expected: algal blooms and turnover which cause the water quality to fluctuate, especially during warmer months of late summer and early fall.

Physical Characteristics. A review of the data for Loch Lomond indicates higher turbidities, color, and odor levels than the San Lorenzo River. In contrast to the San Lorenzo River, high turbidity levels in Loch Lomond take several weeks to months to decrease. Measured turbidity levels have ranged from a high of 100 NTU in 1982 to a low of 0.95 NTU in 1985.

Chemical Characteristics. Annual chemical analyses for Loch Lomond show similar characteristics to the San Lorenzo River in that occasional iron and manganese levels exceed the secondary drinking water standards. The remainder of the reported chemical characteristics are lower than the drinking water standard with the exception of endrin in 1978 (as discussed in the section on the San Lorenzo River).

Biological Characteristics. In contrast to the San Lorenzo River, Loch Lomond is a regulated resource and has typical bacteriological levels less than 2.2 MPN/100 mL and very few samples over 16 MPN/100 mL. As previously discussed for the San Lorenzo River, the presence of an indicator organism is related to the potential presence of human and/or animal disease organisms. These concentrations are low to very low and should be of no concern with proper treatment.

Coastal Sources. As discussed earlier, the coastal source consists of Majors Creek, Laguna Creek, and Liddell Spring. The water quality from these sources is much better than either the San Lorenzo River or Loch Lomond.

Physical Characteristics. Turbidity levels for these sources are normally less than 1 NTU with occasional increases during periods of high runoff. Of the three sources, Majors Creek is the most sensitive and Liddell Spring the least. As an example, in December 1984, the

turbidities for Majors Creek, Laguna Creek, and Liddell Spring were 14.0, 5.4, and 0.18 NTU, respectively.

All three sources, as in the case of the San Lorenzo River and Loch Lomond reservoir, have a negative corrosivity index, which indicates a higher corrosion activity. If the corrosivity is not adjusted in the water treatment processes, corrosion of distribution pipes may result.

In addition to the higher turbidity levels, Majors Creek has had color levels above the secondary standards.

Chemical Characteristics. With the exception of occasional high manganese levels, all three sources have reported chemical concentrations below the drinking water standards. As in the case of the San Lorenzo River and Loch Lomond, the endrin concentration in 1978 was reported as less than 0.005 mg/L.

Biological Characteristics. The bacteriological counts for Liddell Spring are normally less than 2.2 MPN/100 mL. Laguna Creek has a consistently higher count of between 20 to 60 MPN/100 mL and a very few over 1000 MPN/100 mL. Majors Creek has the highest reported bacteriological counts, normally less than 230 MPN/100 mL but occasionally (during storms) increasing to over 1000 MPN/100 mL with one report of over 24,000 MPN/100 mL. With the exception of Liddell Spring, these counts would be of major concern if these sources were used as a drinking water source without treatment beyond chlorination. With proper treatment, these concentrations should be of no major concern with the exception of the over 24,000 MPN/100 mL reported for Major Creek. Because this count was an isolated incident with no other concentrations in the range, it could be considered a bad reading.

Tait Street and Beltz Wells. Although from different aquifers and treated and distributed separately, these two well fields exhibit similar quality characteristics. The Tait Street groundwater supply is treated at the GHWTP, whereas the Beltz groundwater supply has a separate treatment plant.

Physical Characteristics. Although there are different criteria for turbidity for groundwater sources that are not subject to sewage contamination, the annual data for these wells do show higher turbidity levels than would be acceptable for a surface water source. Turbidity levels in excess of 5 NTU have been reported for these sources, which is presently the maximum allowed in a distribution system.

Chemical Characteristics. Both of these well fields have iron and manganese levels in excess of the secondary standard. In the case of the Beltz wells, the Beltz treatment plant is intended for iron and manganese removal. Treatment for the Tait Street wells will be discussed in the Section 5.2.4, Raw Water Treatment.

Biological Considerations. Because neither well field is subject to human contact, no bacteriological levels are expected.

5.2.3 Probable Future Changes in Raw Water Quality

Assessing the future water quality of surface water sources is a difficult task. In the case of the Santa Cruz water sources, one can feel confident that the quality of Loch Lomond and the coastal source will remain fairly stable in the future because development adjacent to each source is controlled. Water quality within the San Lorenzo River is more subject to effects from development. Presently, the development along the river is operating on a septic tank system. If, in the future, these systems are replaced with a treatment plant, the effect of a point source discharge needs to be assessed. This effect would most likely take the form of an increase in the form of organic carbon. These added organics could have an impact on disinfection by-products. Based on historical water quality records, river water quality has been consistent. The County's ongoing "San Lorenzo River Wastewater Management Program" is an important step in safeguarding the river supply and should continue. If continued action is not taken in correcting failing septic tank systems adjacent or tributary to the San Lorenzo River, additional contamination of the river may occur with corresponding deterioration of water quality.

5.2.4 Raw Water Treatment Requirements

Graham Hill Water Treatment Plant. The water quality treatment concerns for the surface sources and the Tait Street groundwater are capable of being addressed by the additions and modifications to the GHWTP. These modifications were very extensive in nature and have provided a high degree of flexibility in the operation of the plant. One significant modification has been the incorporation of a pre-treatment system for taste and odor control by providing rapid mix and mix detention time for either powdered activated carbon or potassium permanganate. Additionally, the installation of a new coagulant chemical rapid mixer, flocculators, and revision of the sedimentation basins have greatly improved operation. The specific water quality concerns were discussed in Section 5.2.1, and the available treatment facilities are discussed below.

Turbidity. Turbidity is removed by the coagulation/sedimentation process which is followed by filtration. Plant modifications have included expansion of the coagulation/sedimentation/filtration facilities, and recent operating data show that high removals of turbidity are achieved.

Color and Odor. In many cases, pre-treatment such as coagulation/sedimentation is effective in controlling tastes, odor, and color. For periods of high taste and odors and high color, two additional treatment options are available to the operators: powdered activated carbon (PAC) and potassium permanganate.

Iron and Manganese. Two options are available for iron and manganese removal/control: pre-chlorination and potassium permanganate. They are both effective oxidizing agents.

Bacteriological. By use of the treatment process of coagulation/sedimentation/filtration followed by chlorine disinfection, the bacteriological treatment requirements are satisfied.

Beltz Wells Treatment Facilities. The treatment facilities at the Beltz Wells consist of air oxidation, chlorination, and filtration for removal of iron and manganese. When operating properly, these facilities are effective in fulfilling this function, but historically have experienced problems with component reliability. SCWD is working to correct this reliability problem.

5.2.5 Treated Water Quality

Graham Hill Water Treatment Plant. Existing water quality data for the GHWTP indicate that all of the USEPA and California primary and secondary drinking water standards are being met. In addition, recent operating data show that the treated water effluent turbidity levels of between 0.1 and 0.2 NTU are commonly achieved. These levels indicate the plant produces excellent finished water.

Distribution System. The treated water quality within the Santa Cruz distribution system meets or exceeds the present water quality requirements discussed in Section 5.3 with the exception of occasional turbidity levels along the North Coast pipeline. There have been isolated occurrences of bacteriological counts greater than 2.2 MPN/100 mL but re-test of the sample point has produced results of less than 2.2 MPN/100 mL.

The trihalomethane (THM) level within the distribution system is below the current 100 ug/L (micrograms per liter) concentration. Quarterly data reported to the California Department of Health Services for the year 1983 through the fourth quarter 1987 range from less than 1 ug/L to 73 ug/L.

5.3 WATER QUALITY REGULATIONS

5.3.1 Summary of Significant Developments in Water Quality Regulations

Federal Standards. In July 1986, Congress passed legislation to renew and amend the Safe Drinking Water Act (SDWA). Overall, the amendments broaden the scope of the original SDWA legislation, strengthen the federal enforcement role, and streamline the regulatory process. The amendments include 83 contaminants required to be regulated (see Table D-1) and establish the first Drinking Water Priority List (DWPL) of future contaminants being considered for regulation. The DWPL was finalized and published in 1988

(see Table D-9). The list consists of 57 contaminants or groups of contaminants that are a cross-section of drinking water contaminants, but the requirements call for 25 additional contaminants to be placed on the subsequent priority lists every 3 years. Constituents of concern on the DWPL are organics, microbiological organisms, and inorganics. The inorganics of concern include aluminum, molybdenum, silver, sodium, vanadium, and zinc. Other items to be considered include disinfectants and disinfectant byproducts (such as THMs). One future change that might occur is a reduction in the THM limits from 0.100 mg/L to 0.05 mg/L or less.

In July 1988, the EPA proposed new requirements to minimize lead and copper in drinking water. The regulations would require testing of the source waters after treatment and testing of households for lead and copper content and pH values. The pH values correlate with the corrosion potential of the water; values less than 8 indicate aggressive water capable of dissolution of lead and copper.

The consequences of the regulations are (1) the list of contaminants to be controlled in the drinking water regulations will be constantly evolving, (2) more sampling and analyses will be required to determine the presence and concentration levels of the specific constituents, and (3) additional methods of control (source control or treatment methodology) will have to be developed for those constituents that exceed the maximum limits.

State Regulations. In addition to the requirements of the SDWA, California prescribes regulations for potable water. Additional constituent limitations are being proposed and are also listed in Appendix D. For some contaminants, California regulations are more stringent that those of USEPA. In addition, California will be issuing a Guidance Manual for surface water treatment that will include treatment requirements, monitoring requirements, design standards, plant operation, and reporting. The design standards may include average daily treated water turbidity goal of 0.2 NTU and a filter-to-waste for each filter unit or the addition of coagulant chemicals to the water used for backwash. Detailed information on the existing and proposed state regulations is also provided in Appendix D.

5.3.2 Impact of New Regulations on the City of Santa Cruz Water Treatment Operations

As stated above, the new regulations will affect the (1) sampling and analyses required, (2) plant operations, and (3) facilities requirements. In this section, the effects on the City of Santa Cruz will be assessed.

Water Quality Sampling and Analyses. With the advent of the new and proposed federal and state regulations, the requirements for sampling, testing, and reporting will be greatly increased. These are divided into routine operational sampling, and annual or one-time analysis and reporting. The specific requirements are described in Appendix D.

The routine sampling programs will be similar to the present procedures practiced by the Water Department. Routine operational sampling, testing and reporting of plant operations will need to be consistent with the state's surface water treatment regulations after they become effective. Because the state and federal regulations are evolutionary, new regulations when issued will have to be examined carefully to ensure the sampling and analysis program is updated and revised to conform to the new requirements.

Certain requirements of the federal and state regulations will require one-time sampling with repeated sampling only if certain contaminant levels are detected or there is a change in the source water quality. Other one-time samplings will require re-sampling after a specified time period.

<u>Operational Modifications</u>. Future operational modifications may be required by future changes in the state and federal regulations. Examples of possible operating modifications include (1) the addition of chemicals to the filter backwash, (2) changes in amount and type of coagulant used, (3) changes in disinfection requirements, and (4) lead/copper/pH requirements.

The proposed state design standards may require the addition of chemicals to the backwash water (or the construction of a filter-to-waste line). Because GHWTP is an existing facility, changes to the backwash system may not be required if the turbidity of the filtered water is 1.0 NTU or less after returning the filter to service following backwash.

One of the constituents of concern to water treatment plant operators is the possible limitation of the aluminum concentration in the treated water. The proposed California regulations indicate a limit of 1 mg/L. Because alum is a principal coagulant in water treatment, strict control may have to be maintained on alum dosages to limit the carry-over to the finished water. If it is very difficult to maintain the level of control necessary to meet this limitation, alternative coagulants will have to be considered such as ferric chloride. Adjustments in type and dosage of coagulant may also affect the pH of the treated water. Operating changes to maintain the pH above 8 for corrosion prevention (and lead and copper control) may have to be made.

Future considerations related to disinfectants and disinfectant by-products as mentioned in Section 5.3.1 may also affect the type of disinfectant used, method of application, and contact time. The disinfectant requirements are based upon a disinfectant dosage times the contact time (referred to as Ct). Three chemical oxidants are available to obtain the Ct values necessary: chlorine, chlorine dioxide, and ozone. Chloramine is an acceptable disinfectant residual; however, to be used as a primary disinfectant, the published Ct values would require extremely high dosages of chlorine and ammonia or extended contact time. Therefore, the type of disinfectant used will have to be investigated to determine the most cost-effective method to

be used to meet the requirements. As a result, changes in plant operating procedures may be required in the future.

When selecting a disinfectant to provide the required Ct value, consideration will have to be given to THM formation. THMs are formed by the reaction between the organic precursor molecule and either chlorine or bromine, with chlorine being the more common in water treatment. If reduction in THM levels below the current 0.100 mg/L is required, the type of disinfectant used may change, which will affect the operational procedures and possibly the treatment facilities required. Therefore, an evaluation of the effects of alternative disinfectants and their water quality impacts becomes an important consideration.

Modifications and Additions to Treatment Facilities. To meet most of the current and proposed regulations, the GHWTP with its recent modifications and improvements is a satisfactory facility. Possible new facilities may be required to meet new and future requirements, particularly as related to disinfection and disinfection by-products. The exact nature of possible additions and modifications required to the plant will depend on additional studies that the SCWD should undertake, as described below, and further clarification from the state of design standards required for retrofitting existing plants.

5.4 RECOMMENDED WATER QUALITY IMPLEMENTATION PROGRAM

5.4.1 Program Purpose

The purpose of the water quality implementation program is to identify the activities necessary (1) to comply with the new regulations; (2) to investigate operational changes or treatment technology necessary to comply with existing, pending, or anticipated water quality regulations; and (3) to identify the facilities necessary to support the operational changes and/or treatment modifications.

5.4.2 Water Quality Monitoring

Numerous organic and inorganic contaminants have been identified for regulation or possible regulation by USEPA and the State of California. The SCWD should include a budget allowance for a monitoring program for periodic sampling and analysis of those constituents listed in the tables in Appendix D. The suggested initial monitoring program for those contaminants not covered by the existing regulations should be done at least once every 3 years or whenever the regulations change, whichever occurs first. Repeat sampling and analyses should be conducted on a follow-up basis if potential contaminants are identified. The monitoring program should be adjusted based on changes to the DWPL.

5.4.3 Watershed Sanitary Survey/Management Program

To comply with the requirement of the surface water treatment act, a sanitary survey of the watersheds that supply water to the GHWTP should be performed. The results of the survey should be used to develop a management program for Loch Lomond watershed, the coastal watersheds, and most importantly, the San Lorenzo River.

5.4.4 Water Supply Operations

As discussed in Chapter 8, the use of the best quality and lowest cost water sources should be maximized, but must be weighed against safeguarding of supplies such as Loch Lomond Reservoir to maximize the system's dry year yield.

Under the operating guidelines discussed in Chapter 8, there may be some effects on the treated water quality. As previously discussed, each of the water sources has a different water quality, although each can be considered as a good quality source. During different times of the year, the blend of the incoming water will vary because of changes in availability or recommended priority of use of each of the sources. For most water quality parameters, there should be little effect on the finished water quality produced by the GHWTP because full pre-treatment is provided. The THM Formation Potential (THMFP) of the raw waters to the plant is expected to vary depending on the seasonal changes in the individual sources and their percentage of the total flow. However, under the proposal operating rules, the THMFP is not expected to be significantly higher than what the plant is experiencing presently.

There are additional concerns as to what will happen in relation to the treated water THM concentrations when treating source waters with turbidities in the range of 25 NTU or higher. Such turbidity levels will be expected relatively infrequently, normally only during or following rainfall when natural erosion of soils is increased. No direct relationship between THM formation and turbidity has been found. Since the organic and inorganic content of the turbidity can vary widely, and THMs are chlorination byproducts of organics, to identify a THM formation potential relationship with high turbidity, laboratory testing should be conducted to characterize the THM formation potential of each of the sources and to verify that the organic content has been increased during high flow periods.

Of the three surface water sources, the North Coast is the best quality and would be expected to have the lowest THM formation potential. Loch Lomond is the second best quality water, but may have seasonal turnovers. During turnovers, which occur usually in the fall, the THM precursor concentration would increase due to mixing of decomposing organic matter on the bottom. Another source of precursors would be seasonal algae blooms. Within the San Lorenzo River, the concentrations of THM precursors is expected to be lower during higher runoff periods than low-flow periods because of the flushing

effect on the decomposing vegetation. During low flows, when the majority of the river flow results from groundwater inflow, the concentration of THM precursors would be expected to be higher due to the pickup of dissolved organic matter in the soil.

Once the incoming regulations are promulgated, a long-term investigation of the seasonal and hydrologic variations' impact on the THM formation potential from each of the sources should be conducted. Such a study would provide a conclusive determination of the impact of the new water quality regulations and proposed operating rules, and would allow for the "fine-tuning" of the blend from the various water sources based on water quality. The results of this investigation should be integrated with the alternative disinfection study discussed below.

5.4.5 Study of Alternative Disinfectants and Effects on THM Formation

The proposed and anticipated regulations for disinfection, THM, and lead/copper/pH have interrelated effects. The study of alternative disinfectants and disinfectant by-products should include the following:

- After the Ct value for disinfection has been published in its final form, a study employing pre-chlorination to obtain the required disinfection should be performed to determine the THM formation potential. The study should be performed to determine the THM concentration at each step in the treatment process as well as at selected points in the distribution system.

- Investigate the use of alternative primary disinfectants such as ozone and chlorine dioxide to obtain the required Ct.

- Investigate the use of chlorine and preformed chloramination as alternative secondary disinfectants at the end of the treatment process to evaluate THM formation in the distribution system and still maintain a chlorine residual.

- Investigate the effect of THM formation at pH values greater than 8 for different pre-treatment and chlorination practices. The THM measurements should correlate with the range of water residence times in the distribution system.

- Perform a cost analysis of the alternative treatment process configurations investigated.

- A bench-scale testing program should be conducted for pre-screening for primary and secondary disinfectants. A pilot plant study should be conducted to evaluate the more promising processes.

5.4.6 Facilities Requirements

Most of the facilities that may be needed to meet the new or anticipated regulations depend on the results of the investigations described above. At this time, it is not known if the proposed state regulations will require the GHWTP to be retrofitted with a filter-to-waste system or if a chemical feed system will be required for chemical addition to the backwash water.

5.4.7 Estimated Cost of Water Quality Program

The estimated additional costs for the recommended investigations and possible facilities improvements are:

- Water quality monitoring program..................$70,000/yr
  - One additional laboratory person ($40,000/yr)
  - Additional sampling and laboratory costs ($30,000/yr)
- Watershed sanitary survey/management program......$90,000
  - 900 person hours ($72,000)
  - Laboratory analysis ($18,000)
- Source THMFP investigation.......................$35,000
  - Sample collection/preparation ($12,500)
  - Laboratory analysis ($12,500)
  - Operations analysis ($10,000)
- Study of alternative disinfectants
  - Bench testing $25,000
    Laboratory, ozonator/reactor ($10,000)
    Chemicals, power ($2,500)
    Sample analysis ($12,500)
  - Pilot plant $150,000
    Pilot plant rental ($20,000)
    3-months operation ($105,000)
    Sample analysis ($25,000)
- Filter-to-waste engineering and construction......$200,000

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Chapter 6

ALTERNATIVES FOR NORTH COAST DOMESTIC SERVICE

6.1 BACKGROUND

In acquiring water rights for the North Coast streams, which were originally obtained in the late 1800's, the City of Santa Cruz agreed to furnish water supply service along the North Coast in exchange for the riparian water rights. These agreements are embodied in written documents which the City Attorney considers to be legal and binding. Consequently, the SCWD has continued to provide water service along the North Coast, both for domestic and agricultural irrigation use.

The domestic water supply has historically been provided directly off the Coast Pipeline, which carries untreated water from the North Coast sources into Santa Cruz. Due to excellent water quality in the North Coast sources, SCWD has been able to provide an acceptable quality for domestic consumption with only chlorination at the source for disinfection. However, because acceptable water quality must be maintained at all times for the domestic services, the North Coast supply system must frequently be shut down during the rainy season when surface runoff becomes too turbid ("dirty") for domestic use. During such periods, water from SCWD's other sources is delivered to both domestic and agricultural users along the Coast Pipeline from Bay Street Reservoir via the University pumping system. Because SCWD is unable to divert water from the North Coast during such periods, use of other more costly supplies and depletion of valuable storage at Loch Lomond Reservoir is required. Therefore, from both economic and water supply standpoints, it would be advantageous to provide <u>domestic</u> water service in a different manner in order to utilize the Coast Pipeline as a true raw water transmission pipeline without the stringent turbidity constraints during the rainy season. Agricultural users could continue to draw off the Coast Pipeline since the turbidity standards for this use are considerably lower than for domestic consumption.

As described in Chapter 5, changes in federal and state drinking water standards will require filtration (i.e, treatment) for all surface water supplies. Therefore, the State has issued a mandate to the SCWD to provide adequate treatment for the North Coast domestic service, using either the existing North Coast sources or an alternative source of supply. The identification and evaluation of alternatives available to the SCWD for providing domestic service on the North Coast was included in this master plan study in response to the State's mandate. Based on the aforementioned legal agreements, it was assumed in this study that the SCWD will have to continue providing domestic (and agricultural) service along the North Coast.

To further complicate the problem, the North Coast domestic users are spread out over a 5-mile distance along the Coast Pipeline. There are approximately 25 domestic users along the pipeline, with about 15 of these clustered together in the Jolly Spur area. The remaining 10 connections are scattered between the Liddell-Laguna "Y" and Wilder Creek.

The alternatives identified in this study are described and evaluated in the following sections. As indicated above, the alternatives focus on options for providing domestic water service only. Agricultural users will continue to be served directly off the Coast Pipeline.

6.2 DESCRIPTION OF ALTERNATIVES

6.2.1 General

Based on bi-monthly meter records compiled for 1986-88, the total water use for <u>current</u> domestic services along the North Coast is less than 8 MG per year or an average of about 15 GPM, a negligible portion of the total production from the North Coast supply system. It has been assumed that no future domestic connections will be allowed along the Coast Pipeline. Therefore, the estimated maximum day demand for which water supply facilities must be designed is only about 50 to 75 GPM. Therefore, the amount of supply and distribution capacity needed to serve the domestic is extremely small. The domestic water system will <u>not</u> be required to serve agriculture and fire protection needs along the Coast Pipeline.

Five alternatives for supplying water to the domestic services were formulated. These alternatives include treatment of all or a portion of the North Coast supplies at or near the source or at the point of use, construction of local, low-capacity groundwater wells, and delivery of water from the main SCWD distribution system via Bay Street Reservoir and the University system. The five alternatives considered in this study are listed in Table 6-1. A map of the North Coast area and the required facilities for each alternative are shown on Figure 6-1.

One other alternative which was considered in this study is the use of individual domestic wells (one at each domestic service). Because no additional pipelines would be needed, the capital cost of such a plan may be relatively low. However, because of the aforementioned legal agreements, SCWD would likely have to own and operate each well. The cost of maintaining up to 20 individual wells would be considerable. While some domestic customers may agree with such a plan, it is doubtful that all would. There also is no assurance that development of wells which produce adequate quantity and quality of water on a continuing basis could be accomplished at every customer location. Therefore, this plan was considered impractical and will not be evaluated further.

Table 6-1

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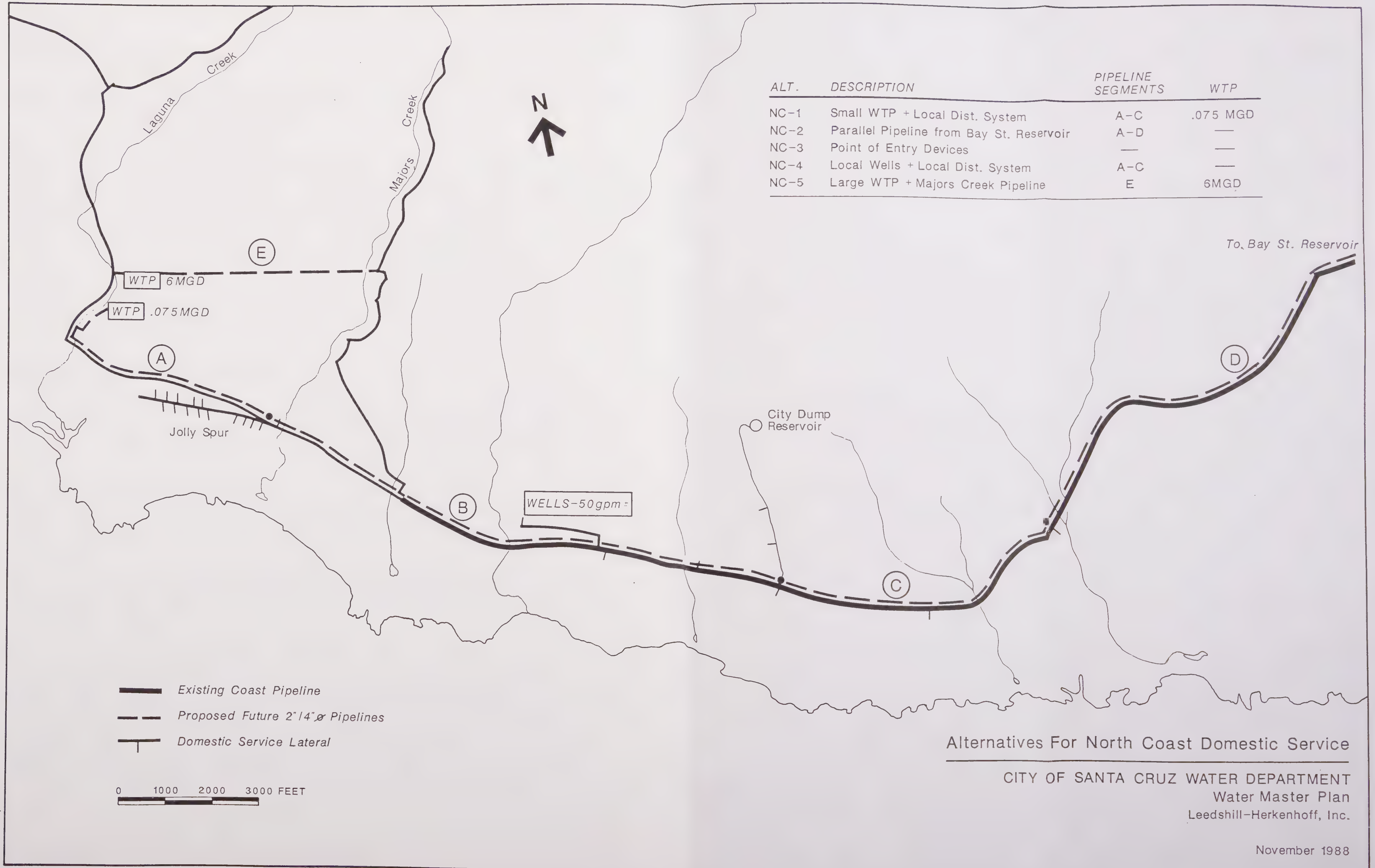
ALTERNATIVES FOR PROVIDING DOMESTIC SERVICE
ALONG NORTH COAST PIPELINE

Alternative	Description
NC-1	Construct small package WTP near Laguna-Liddell "Y" and local distribution system
NC-2	Construct parallel pipeline from Bay St. Reservoir to Laguna Creek
NC-3	Install point-of-entry devices for domestic services
NC-4	Install local groundwater well(s) and distribution system
NC-5	Construct complete 6-MGD WTP near Laguna-Liddell "Y"

FIGURE 6-1



ALT.	DESCRIPTION	PIPELINE SEGMENTS	WTP
NC-1	Small WTP + Local Dist. System	A-C	.075 MGD
NC-2	Parallel Pipeline from Bay St. Reservoir	A-D	—
NC-3	Point of Entry Devices	—	—
NC-4	Local Wells + Local Dist. System	A-C	—
NC-5	Large WTP + Majors Creek Pipeline	E	6MGD

Alternatives For North Coast Domestic Service

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The following subsections contain descriptions and evaluations of each of the alternatives evaluated in this study.

6.2.2 Alt. NC-1: Package WTP and Local Distribution System

Under this alternative, a small portion of the flow from Liddell Spring and Laguna Creek would be diverted off the Coast Pipeline and treated at a small "package" water treatment plant (WTP) constructed downstream of the confluence of the Laguna and Liddell pipelines (Laguna-Liddell "Y"). The WTP would only have to be capable of treating 0.075 MGD, roughly the equivalent of the maximum day demand for all current domestic users on the Coast Pipeline. A local distribution system consisting of approximately 4.8 miles of pipelines parallel to but independent of the existing Coast Pipeline and its branches would be constructed to deliver the treated water to the domestic services. The distribution pipeline would begin at the package WTP and extend to the furthest domestic service near Wilder Creek. All domestic services would have to be disconnected from the existing Coast Pipeline and re-connected to the new, smaller pipelines.

The distribution pipeline would be 4 to 6 inches in diameter from the package WTP to the Jolly Spur area, where a cluster of domestic services are located. From this point, a 2-inch diameter pipeline could be used. No pumping will be required along the distribution pipeline if the package WTP is located at a sufficiently high elevation. A new storage tank would be used to balance supply and demand in the new distribution system. The existing 100,000 gallon Coast Reservoir, which is no longer used, could be relocated near the Jolly Spur area to reduce costs.

Under this alternative, North Coast diversions not used by the North Coast domestic services (virtually all) will continue to flow through the Coast Pipeline into the SCWD system for treatment at GHWTP. During emergencies, water could be delivered up the Coast Pipeline from the SCWD University system as is currently done during periods of excessive turbidity.

The package WTP will present special operational problems and additional costs associated with sludge disposal and labor costs for operating personnel. Also, a small parcel of land would have to be obtained for the package WTP and the storage reservoir.

6.2.3 Alt. NC-2: Parallel Pipeline from Bay St. Reservoir

In this alternative, water treated at GHWTP would be delivered to the North Coast domestic services through a parallel, independent pipeline extending from the existing Bay Street Reservoir. Due to the additional distance between the last domestic connection and Bay Street Reservoir, a total of about 6.7 miles of pipeline would be needed, about 1.9 miles more than under the prior alternative. Water from Bay Street Reservoir would be pumped through the University system from which it would flow into the new pipeline for distribution to all domestic users along the North Coast.

The new pipeline would be 4 to 6 inches in diameter between Bay Street Reservoir and Jolly Spur, then 2 inches in diameter to the last domestic user near Laguna Creek. Again, a new storage tank should also be constructed in the North Coast area to balance supply and demand.

The existing Coast Pipeline would be completely independent of the new distribution pipelines once the domestic services are disconnected. All diversions from the North Coast sources would be treated at GHWTP.

Although this alternative may present relatively high construction costs, operation and maintenance costs will be much lower than other alternatives since no additional production facilities are needed and the system would be entirely independent from other North Coast operations.

6.2.4 Alt. NC-3: Point-of-Entry Devices

To avoid the high capital costs of constructing parallel pipeline systems or adding new production facilities, the domestic connections along the Coast Pipeline could be outfitted with "point-of-entry" treatment devices in order to provide acceptable water quality at all times. These devices essentially provide decentralized, on-site treatment for domestic water supplies and can offer a cost-effective alternative for small, rural water systems such as SCWD's North Coast system. No other facilities would be needed under this alternative.

The point-of-entry devices suggested for use in the SCWD system would consist of multi-layer filtering media in a tubular cartridge approximately four feet in length. The devices would be installed in the domestic service laterals off the Coast Pipeline, presumably near the meter box. The devices could be mounted on a small concrete pad or could be buried in a concrete vault. Automatic back-washing systems with timers are also available to reduce operating costs.

Point-of-entry devices are essentially miniature WTPs and can be designed to handle a variety of contaminants. Different technologies are available based on the specific contaminants that need to be removed from the drinking water. The devices are able to provide treated water effluent which meets the federal drinking water standards in most cases and are reportedly capable of treating water with turbidities up to 100 NTUs.

To reduce costs, particularly with respect to water quality monitoring (see below), the cluster of domestic services along Jolly Spur would be served through a common set of devices or from one larger device capable of treating about 20 GPM. Due to the scattered locations of the other domestic services, eleven individual devices would be needed along the Coast Pipeline in addition to the Jolly Spur location. Individual devices capable of treating up to about 10 GPM cost about $1,000 apiece. If the domestic services have landscape irrigation systems, more than one device would be needed for each connection.

Due to the lack of major construction, this alternative offers very low capital costs relative to the other alternatives. However, there are several significant drawbacks which also must be considered:

(1) The SCWD would have to own and operate the point-of-entry devices and would be responsible for daily monitoring of turbidity and weekly monitoring of bacteriological conditions. In essence, the SCWD would be responsible for operating up to 15 additional WTPs and the associated water quality monitoring standards. These monitoring requirements would require a substantial amount of additional labor and equipment, and could likely inconvenience the North Coast domestic customers.

(2) The filter media in each device would have to be changed once a year or sooner, depending on the exact chemical makeup of the raw water.

(3) There is no certainty that point-of-entry devices can meet current drinking water standards at all times, particularly during rainy periods when turbidity is high. High levels of turbidity could quickly clog the filters, interfere with chlorination disinfection, or require that the sources be shut down at times. Therefore, the devices may not present a complete solution and could impact the SCWD's diversions from the North Coast since the Coast Pipeline may need to be used to deliver the domestic water from Bay Street Reservoir.

(4) Point-of-entry devices are typically not considered to be permanent solutions by regulatory agencies unless all other alternatives are cost prohibitive. Also, under potential future changes in state and federal drinking water regulations, such devices may no longer provide adequate treatment.

6.2.5 Alt. NC-4: Local Groundwater Wells and Distribution System

Because the water demand of the North Coast domestic services is small, low-yielding local groundwater wells could be used to supply the entire demand for these services. The local water demands could be satisfied by construction of two shallow wells capable of about 50 GPM apiece. In addition to constructing the wells, a local distribution system similar to that described in Alternative NC-1 would be required, including a new storage tank. For purposes of this study, it is assumed that the only treatment required is chlorination for disinfection. However, iron and manganese removal may also be needed.

This alternative is similar to Alternative NC-1 but uses small wells to produce the required water supply, thereby allowing the existing Coast Pipeline to operate as a true raw water transmission pipeline. The major

drawback to this alternative is the uncertainty of groundwater conditions along the North Coast. Although the wells will only draw small quantities of groundwater, several wells along the North Coast run dry in late summer and/or have poor water quality. Therefore, the availability of adequate well sites is uncertain. SCWD would also have to operate and maintain the wells.

6.2.6 Alt. NC-5: North Coast Water Treatment Plant

Under this alternative, a full-scale WTP would be constructed near the Laguna-Liddell "Y" to treat water from all three North Coast sources at a central location. The WTP would be designed to treat up to 6 MGD, the maximum total diversion from the three North Coast sources under current conditions. A lengthy new pipeline would have to be constructed to convey diversions from Majors Creek to the WTP. The existing Coast Pipeline downstream of the WTP would then be transformed into a treated water pipeline, providing both domestic and agricultural services with treated water.

Besides providing treated water to the North Coast domestic services, this alternative would also provide treated water to the western portion of the SCWD system, helping to fill Bay Street Reservoir in order to maintain adequate delivery pressures. Therefore, any reduction in costs for distribution system improvements due to the impact of the North Coast WTP should be "credited" against the capital cost for this alternative. Because GHWTP has adequate capacity for the planning period, no further advantage is gained by having a second major WTP other than reliability.

As with the package WTP in Alternative NC-1, special problems with sludge handling, land acquisition, and operating personnel labor would be present, and to a much greater degree.

6.3 COST ESTIMATES

Reconnaissance-level cost estimates were developed for each of the five alternatives described above. All anticipated capital construction costs and operation and maintenance (O&M) costs were included. A 20 percent contingency and 15 percent for engineering, legal, and administrative work were added to the base construction cost estimate. Unit costs were obtained from manufacturers, recent pipeline and well construction jobs, standard cost estimating manuals, and discussions with SCWD staff for labor costs. The small diameter distribution piping needed for Alternatives NC-1, NC-2, and NC-4 was assumed to be polyvinyl chloride (PVC). Due to the small quantities of water supply involved, differences in energy costs are negligible and, hence, were not included.

A summary of the cost estimates is shown in Table 6-2. The breakdown between capital and O&M costs is given due to the large differences between the alternatives. A 30-year present worth of estimated annual O&M costs is

Table 6-2

City of Santa Cruz Water Department
Water Master Plan

ALTERNATIVES FOR NORTH COAST DOMESTIC SERVICE
SUMMARY OF COST ESTIMATES

Alternative	Description	Total Capital Cost	Present Worth of 30-yr O & M	Total Present Worth
NC-1	0.075 MGD WTP + Local Distribution System	$720,000	$474,000	$1,194,000
NC-2	Parallel Pipeline from Bay Street Reservoir	$671,000	$51,000	$722,000
NC-3	Point-of-Entry Devices	$61,000	$729,000	$790,000
NC-4	Local Wells + Local Distribution System	$596,000	$136,000	$732,000
NC-5	6 MGD WTP + Majors Creek Pipeline	$3,011,000	$896,000	$3,907,000

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used for comparison to the capital construction costs. As indicated, Alternatives NC-2, NC-3, and NC-4 are relatively similar in total cost, with present worths between $722,000 and $790,000. Alternative NC-1 is over $400,000 more costly than the three lowest cost alternatives while Alternative NC-5 is considerably more expensive than all other alternatives. Detailed cost estimates are included in Appendix F.

Of the three lowest cost alternatives, NC-3 has the lowest capital cost by far. However, the extensive amount of labor costs required for monitoring and maintaining the point-of-entry devices more than offsets the savings in capital cost when present worth costs are considered. Alternative NC-2 has a slightly higher capital cost than Alternative NC-4 but a considerably lower O&M cost.

6.4 ENVIRONMENTAL IMPACTS

Of the five primary alternatives considered, only one would be expected to have significant adverse environmental impacts. The first four alternatives involve relatively minor facilities which are hardly noticeable and will not have a growth-inducing impact. Only minor inconveniences such as traffic disruption and additional noise and dust during construction could be considered to be adverse impacts. The additional groundwater wells envisioned under Alternative NC-4 could also have an adverse effect on groundwater levels, particularly when considering cumulative impacts. However, Alternative NC-5 presents the most significant environmental impacts. In addition to the one acre or so of land which would be needed to construct the WTP, this alternative could provide significant growth-inducement, primarily along the North Coast.

Because diversions from the SCWD's North Coast sources will increase slightly, some minor adverse impacts to biological resources may be present. However, the increased diversions will only occur during high runoff periods so any depletion in streamflow should have a negligible effect on fisheries, vegetation, and lagoon habitat.

6.5 RECOMMENDATIONS

Five alternatives were considered in this study to provide domestic service along the North Coast. Because of its relatively low present worth of costs and ease of construction and operation, it is recommended that Alternative NC-2, construction of a parallel pipeline extending from Bay Street Reservoir, be implemented. Although other alternatives offer lower capital costs, this alternative is competitive in overall costs when O&M costs are considered. Also, Alternative NC-2 is by far the simplest plan from an operations standpoint and will not present any "hidden" problems in the future. Furthermore, the SCWD has obtained a state loan which presumably can be applied to construction of this pipeline to reduce the effective capital cost.

Chapter 7

DESCRIPTION OF WATER SUPPLY ALTERNATIVES

7.1 GENERAL

This chapter contains descriptions of the numerous alternatives considered in this study for increasing the production capability of the SCWD water supply system within acceptable standards. Evaluations of the viable alternatives, including yield studies and cost estimates, are discussed in Chapter 8. This chapter focuses on explaining the conceptual plan and required facilities for each water supply alternative.

Each of the water supply alternatives were evaluated for their ability to meet the projected future demands in Year 2005 described in Chapter 2. A list of the alternatives evaluated in this study and the identification number assigned to each is provided in Table 7-1. The location of each of these facilities is shown in Figure 7-1. Other alternatives not included in this table were also considered but are not believed to be viable alternatives. Although there may be other potentially viable alternatives, this list represents a variety of the most effective possibilities for increasing the supply capability of the SCWD system. As directed by the City Council, the Zayante Creek Dam Project was not considered in this study.

The alternatives listed in Table 7-1 can be separated into two distinct categories: (1) projects that would develop additional water supplies by better utilization or "optimization" of facilities and water rights associated with water supply sources currently developed by SCWD or others and (2) projects which would require development of new water supply sources. By optimizing the use of existing facilities and sources, the costs and environmental impacts of increasing water supply production would presumably be minimized. If such projects were inadequate to meet future demands within an acceptable level of service or reliability, then additional new sources would have to be investigated.

The list of water supply alternatives was developed by careful review of existing facilities and sources of supply, both within the SCWD system and other nearby systems. The COUNTY MP and numerous other technical reports (see Appendix A) provided a great deal of information on various water supply systems and alternative projects. Potential sources outside of Santa Cruz County (e.g., San Felipe Project) were not evaluated because of the long transmission distances and significant political and institutional obstacles.

As is customary in water supply studies, a "base case" condition was used to compare the relative merits of each alternative. The "existing" condition is typically used as the base case and all other alternatives are compared

Table 7-1

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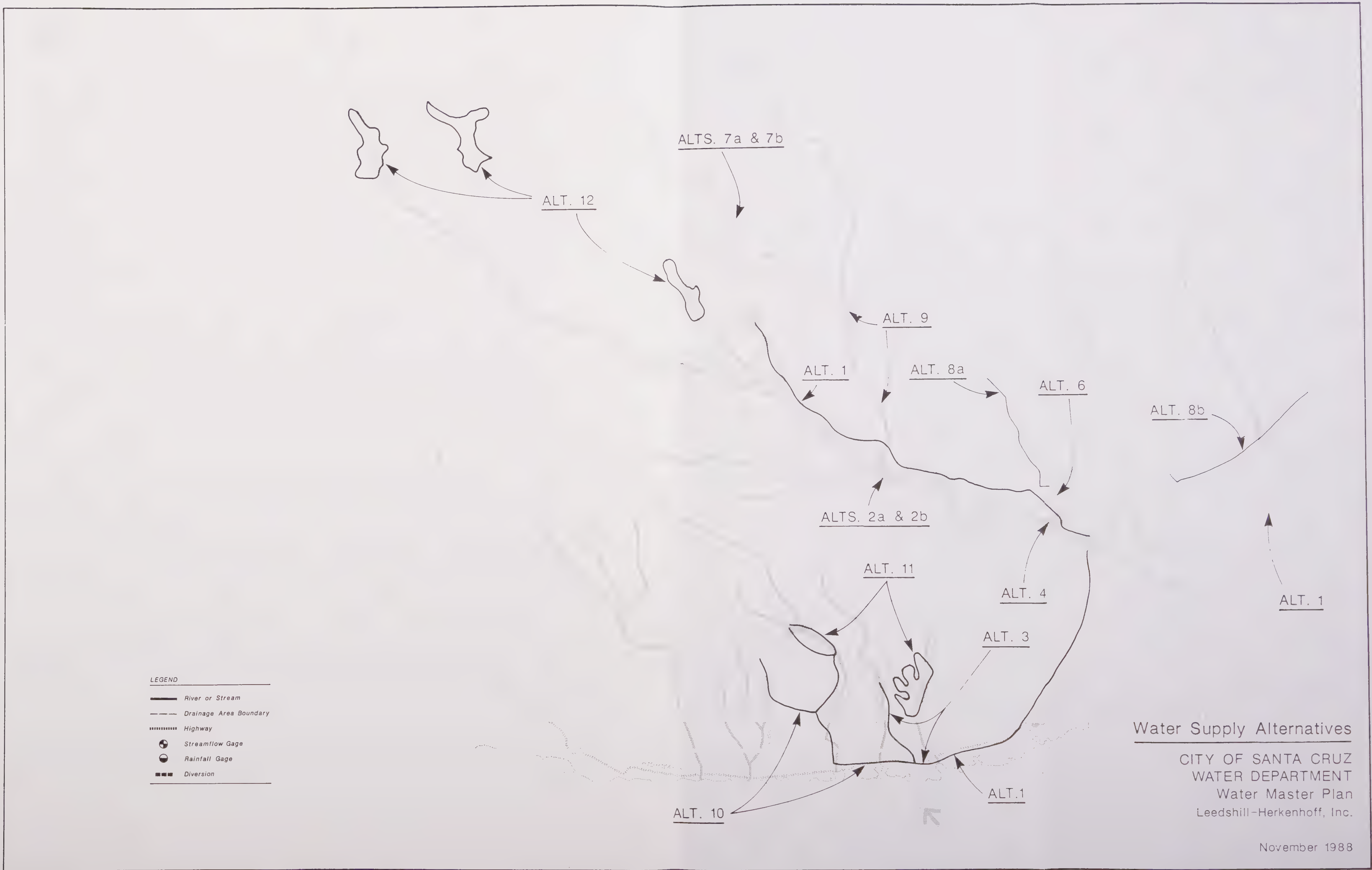
WATER SUPPLY ALTERNATIVES

Alternative No.	Description
1	Upgrade Existing Supply System 1/
2A	Increase Capacity of Felton Diversion
2B	Reduce Operating Margin at Felton Diversion
3	North Coast Pump Stations
4	Parallel Pipeline from SLR to GHWTP
5A	Groundwater Wells and WTP near Thurber Lane (Purisima wells)
5B	Groundwater Well in Harvey West area
6	Wastewater Reclamation
7A	Enlarge Loch Lomond Reservoir by 260 MG
7B	Enlarge Loch Lomond Reservoir by 1010 MG
8A	Scotts Valley Intertie
8B	Soquel Creek Intertie
9	Direct Diversion on Zayante Creek
10	Parallel Coast Pipeline
11	North Coast Reservoir
12	Upper San Lorenzo River Reservoir

1/ Upgrade includes proposed operating rules, two additional pumps at Felton Booster Station, elimination of 1 NTU turbidity limit on North Coast sources, and additional maintenance of key production facilities, particularly during drought years.

tbl7-1/ros2a



Water Supply Alternatives

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to the "Do Nothing" alternative. However, in this study, existing conditions within the SCWD supply system would have been difficult to define and evaluation of these conditions would have been of limited value since the SCWD supply system is currently in a state of transition. Due to new drinking water standards for surface water treatment, the SCWD has received a mandate from the State to modify the domestic service along the North Coast (see Chapter 6). These modifications are expected to slightly increase the water supply production from the existing North Coast facilities. Also, the production capability of the Beltz well system has fluctuated widely over recent years due to operation and maintenance (O&M) problems. Finally, and perhaps most significantly, SCWD does not have a set of formal operating guidelines. Most operating decisions are made from judgement and past experiences. Therefore, simulation of the existing system and procedures would have been difficult and of little value since the actual existing conditions will be short-lived.

For the reasons described above, the base case representative of existing or near-term conditions was assumed to include several modifications or "upgrades" to the existing water system. These modifications or upgrades are assumed to be required measures which will which significantly enhance the capability of the water supply system. Because these upgrades are not part of the current system, this base case is defined as Alternative 1 and is described in the following section. However, this base case condition is inherently included in all subsequent supply alternatives.

7.2 ALTERNATIVE 1 - UPGRADE EXISTING SUPPLY SYSTEM

To maximize production from the existing SCWD water supply sources and to meet the State mandate regarding the North Coast domestic service, several "upgrades" to the existing water supply system are required. These upgrades which constitute Alternative 1 include changes in the North Coast domestic service (which will allow increased water diversions), revised operational procedures, improved maintenance practices at key production facilities, and addition of facilities to the existing production system. Each of these components are addressed individually in the following subsections. Again, the upgrades proposed for Alternative 1 will be included in all other water supply alternatives since they are required or highly beneficial measures.

It should be noted that the upgrades proposed in this alternative will significantly enhance the yield capability of the SCWD's water supply system in both average and dry years. Therefore, direct comparison of Alternative 1 to the performance of the SCWD system in the past or present is not valid.

7.2.1 North Coast Diversions

As presented in Section 6.4, a parallel pipeline along Highway 1 from Bay Street Reservoir to Laguna Creek should be constructed to serve the domestic customers along the Coast pipeline. By removing these customers from the

Coast pipeline, SCWD will be able to divert raw water with turbidities up to 25 NTUs or so during high runoff periods. Under current conditions, the raw water diversions must be "turned out" (shut down) whenever turbidities reach 1 NTU due to water quality considerations for the domestic users. Turbidity levels of over 1 NTU may persist for long periods after a rain storm and, thus, with the present facilities the resultant shut-down significantly decreases diversions from the North Coast. Because water must be diverted from Loch Lomond Reservoir to replace the decreased North Coast diversions, less water is presently available from the reservoir for the critical summertime period.

7.2.2 Operating Procedures

As explained in detail in Appendix E and the Operations Manual, a set of operating rules was developed as part of this study to optimize the use (i.e., yield) of existing water supply facilities and sources. The recommended operating procedures take into consideration that the North Coast and San Lorenzo River sources have no storage facilities whereas Loch Lomond Reservoir and the Beltz Wells can be run at full capacity at any time. The North Coast sources were used to the maximum extent possible because of their superior quality and low production costs relative to the other sources. The primary objective of the recommended operating rules is to keep Loch Lomond Reservoir as full as possible at all times since it is the only significant storage facility which can be used to safeguard against droughts.

As part of the overall operating procedures, a specific rule for deciding when to operate Felton Diversion was developed using historical data. Also, in order to balance water quality and cost considerations with firm yield, an operating rule was developed for deciding whether to use Loch Lomond Reservoir or the Beltz well system as the "second or third call" after the North Coast sources. All recommended operating rules developed for optimizing the use of existing facilities and sources within the SCWD water production system are presented in Section 9.2.4.

7.2.3 Maintenance

Due to power outages, unscheduled maintenance and repair, or required routine maintenance, water supply facilities are not available for use 100 percent of the time. The term "down time" has been used in this study to represent the percentage of time a given facility or source of supply is out of operation on an average basis. By minimizing down times, particularly during drought periods when the availability of all production capacity is critical, the need for additional facilities or sources of supply can be eliminated or delayed.

Through discussion with SCWD operating personnel and administrative staff, a down time for each source of supply in the SCWD was assumed. These down

times were subsequently applied to the theoretical capacity of each production facility in order to not overestimate water supply production. Of particular significance is the value assumed for the Beltz well system, including the water treatment plant (WTP). Although designed to operate at flow rates up to 2 MGD, the Beltz WTP has rarely operated above 1 MGD in the past. However, SCWD believes that production at the Beltz WTP can be sustained at 2 MGD for prolonged periods if necessary. Therefore, an assumed down time of 10 percent was used for the Beltz source. In essence, the Beltz system is assumed to produce 1.8 MGD on an average basis.

<u>Additional maintenance personnel and equipment may be needed in the future to maintain the assumed down times, particularly at Beltz wells.</u> Although specific costs cannot be estimated, they should be extremely low relative to the value of the additional water produced by minimizing down times. In order to reduce the likelihood of sustained outages, it is assumed that increased maintenance for all sources and facilities will be provided such that the assumed down times are valid.

7.2.4 Additional Pumps at Felton Booster Station

As indicated in Chapter 4, the maximum production rate from Loch Lomond Reservoir to Graham Hill WTP is limited to about 7 to 9 MGD with all six pumps operating at the Felton Booster Station (Felton BS). Because Loch Lomond is used for meeting peak demands in the summertime, the required capacity to meet future demands in dry years (when Loch Lomond diversions are greatest) may be as high as 12 to 14 MGD. Therefore, unless additional conveyance capacity is added, the level of demand which can be met by the existing system will be greatly diminished. For this reason, the pumping capacity at the Felton Booster Station was assumed to be upgraded by installing two 300-HP pumps at the booster station to provide up to 16 MGD of conveyance capacity from Loch Lomond Reservoir to the Graham Hill WTP. Through discussion with SCWD staff and review of construction drawings, installation of the two new pumps would appear to only require minor modification of the pump building and piping. The existing transmission pipelines also appear to be adequate.

7.3 ALTERNATIVE 2A - INCREASE CAPACITY OF FELTON DIVERSION

By having greater diversion capacity available at Felton Diversion to move water into Loch Lomond Reservoir, the ability of the supply system to meet peak demands in dry years should be increased. Therefore, increasing the capacity of the Felton Diversion was considered to be a viable alternative.

As noted earlier, SCWD as the right to divert up to 20 CFS at Felton Diversion but the design pressure of the transmission pipeline adjacent to Felton BS restricts the <u>theoretical</u> capacity to about 9 CFS (about 6 MGD) in order to prevent over-pressurizing the pipeline. Based on a review of historical records, SCWD has diverted above 9 CFS at times with, presumably, no harm to

the pipeline. Most pipelines are designed with a factor of safety so operating the pipeline slightly above its design pressure is not necessarily dangerous. However, to achieve a significant increase in the diversion capacity from Felton Diversion, a second parallel pipeline for all or part of the distance between Felton BS and Loch Lomond Reservoir may be needed.

Parallelling the entire distance from Felton BS to Loch Lomond Reservoir would require approximately 15,000 feet of 22-inch diameter pipe rated at 150-175 psi. A more practical, low-cost alternative would be to parallel or replace only the limited portions of the existing pipeline which are theoretically over-pressurized when diverting at 14 CFS. Such additional pipelines would allow diversions up to about 14 CFS when the reservoir was nearly full (slightly higher rates when the reservoir level is low) while operating within the design pressure of the pipeline. If the new pipeline is connected with the existing pipeline, valves would have to be installed to automatically close the existing pipeline when Felton Diversion is operating. An added advantage of this alternative is that both pipelines could be used to withdraw water from the reservoir, thereby increasing the reliability and hydraulic capacity of the source. However, the additional pumps at Felton BS required for Alternative 1 would still be needed.

7.4 ALTERNATIVE 2B - REDUCE OPERATING MARGIN AT FELTON DIVERSION

The existing pumps at Felton Diversion are capable of pumping at a minimum rate of 3 to 4 CFS. To ensure that the river flows do not drop below the minimum required fish flow rate (20 CFS) when the pumps are turned on, SCWD staff indicated that diversions from Felton are usually made only when river flows are approximately 27 CFS. In other words, there is a 7-CFS "operating margin." To reduce this operating margin, a smaller pump with a 1- to 2-CFS capacity could be installed or a variable speed drive (VSD) could be installed on one of the existing pumps. A VSD varies the motor speed of a pumping unit to, in effect, make a given pump behave as a much smaller pump if desired.

During critically dry years when the water is most sorely needed, flows in the San Lorenzo River at the Felton Diversion (essentially identical to the flow at the Big Trees gage) can often fall between 20 and 27 CFS. The following table indicates the number of days between January and May (typical diversion season) of the selected critically dry years that the flow at Felton Diversion fell between 20 CFS (minimum fish release) and 27 CFS (minimum flow for diversion under current operation):

Water Year	No. of Days with flow between 20-27 cfs
1948	45
1961	53
1976	60
1977	13

Assuming an average flow of 23 CFS on these days and a 1-CFS operating margin, up to 80 MG of water was "lost" due to the 7 CFS operating margin in critically dry years. If the late fall-early winter period of a second consecutive dry year is considered, the potential water savings may be far greater. If a small pump or VSD were installed, this additional water could be obtained for use during severe drought periods. Without a reduced operating margin, 1 to 7 CFS of divertable flows now bypass the diversion. Review of the San Lorenzo River flow record indicates that for the 1976-77 critical period, elimination of the operating margin may have resulted in an increase of over 150 MG for diversions from Felton.

Under this alternative, a VSD would be installed at one of the existing Felton Diversion pumps to adjust the discharge rate to capture the smaller flows. In the yield studies discussed in Chapter 8, a 1-CFS operating margin was assumed for this alternative.

7.5 ALTERNATIVE 3 - NORTH COAST PUMP STATIONS

As noted earlier, the diversions from the North Coast sources flow by gravity to the Coast Pump Station for delivery to GHWTP. Because the elevation of the Majors Creek Diversion (352 feet) is low relative to the Laguna Creek Diversion (620 feet) and Liddell Spring (583 feet), diversions from Majors Creek are limited by the hydraulic pressures in the Coast Pipeline exerted by the higher-elevation sources. Under low flows, the hydraulic grade line (HGL) at the intersection of the Majors Creek Pipeline and the Coast Pipeline is well above 352 feet, thus preventing inflow from Majors Creek. Diversions from Majors Creek are only possible under periods of high flow, when the HGL at the intersection of the Majors Creek pipeline and the Coast Pipeline is less than 352 feet in elevation, which requires about 270 feet of friction loss in the Coast Pipeline between the Laguna Creek Diversion and the Majors Creek Pipeline.

The hydraulic limitation on diversions from Majors Creek may be eliminated by installing a pump station at the Majors Creek Diversion to boost the HGL. Due to the flat slope at the upper end of the Majors Creek Pipeline, the pump station must be located at or very close to the diversion. This plan has been suggested before and was included in the SCWD's capital improvement program.

The original plan for the Majors Creek Pump Station described in the COUNTY MP consisted of one pump station at the Majors Creek Diversion. However, based on use of the hydraulic network computer model described in Section 4.4, the installation of only the one pump station on Majors Creek would provide about 3.4 CFS of capacity for diversions from Majors Creek under maximum flow but would also reduce the diversion capacity from the upper Coast sources by about 1.3 CFS (pump station causes higher HGL at intersection which reduces available head loss). Therefore, in designing this

alternative, hydraulic analyses were conducted on a possible second booster pump station located just "downstream" of the intersection of the Majors and Coast pipelines.

The alternative selected for evaluation in this study is construction of a 50-HP pump at the Majors Creek Diversion and a 200-HP pump station on the Coast Pipeline. This configuration was selected so that the maximum capacity of gravity flows from Liddell Spring and Laguna Creek would not be significantly reduced. This pumping arrangement would provide maximum capacities of 4.2 CFS for the Majors Creek Diversion and 13.4 CFS for the three North Coast sources as a whole, compared to the current capacity of 9.4 CFS. Due to the hydraulic interaction downstream of the Coast Pump Station, this plan would cause a slight decrease in capacity for the Tait Street Diversion when both sources are operating at full capacity.

7.6 ALTERNATIVE 4 - PARALLEL PIPELINE FROM SLR TO GHWTP

A second pipeline between the Coast Pump Station near the San Lorenzo River and the GHWTP was considered to be a viable alternative for the following three reasons:

(1) Because both the North Coast and Tait Street Diversions flow through the same pipeline between the Coast Pump Station and Graham Hill WTP, some hydraulic interaction occurs. This interaction affects the production capacity of each source, reducing the total potential diversion capacity by about 1 CFS under maximum flows.

(2) The majority of the SCWD's water supplies are conveyed to GHWTP through a single transmission line for a length of about 6000 feet, including a single, 20-inch diameter undercrossing of the San Lorenzo River. A second parallel pipeline would provide greater reliability. If a second pipeline is added, the current piping configuration could be easily modified to use the existing 16-inch diameter river undercrossing from the Tait Wells in reverse to increase the system's hydraulic capacity and reliability.

(3) The additional capacity provided by a second pipeline would reduce energy costs for both North Coast and SLR diversions, and would improve operation of the Tait wells. Adequate capacity at the Tait wells could be instrumental in minimizing withdrawals from Loch Lomond Reservoir during winter rainfall when the surface water diversions must be shut down due to excessive turbidity. Due to their poor condition, SCWD is considering complete rehabilitation for these wells.

This alternative would require about 6000 feet of 16-inch diameter pipe. Although a parallel pipeline under this plan would provide redundancy and

improve operational efficiency, no significant increase in system yield would be expected.

7.7 ALTERNATIVE 5 - ADDITIONAL GROUNDWATER WELLS

In the last ten years, the SCWD has conducted numerous groundwater investigations in the Santa Cruz area in an attempt to develop additional groundwater supplies. Several different groundwater aquifers in the region have been studied. These include the the Purisima formation on the eastern edge of the SCWD service area, the San Lorenzo River Alluvium, and various sub-basins along the North Coast. Most recently, Luhdorff and Scalmanini Consulting Engineers (L&S) conducted a groundwater investigation and exploration in several areas. Based on the results of L&S's work, SCWD staff suggested that the following groundwater projects be evaluated in this Water Master Plan study:

(A) Two wells in the Purisima formation in the vicinity of the Thurber Lane Pump Station, each capable of producing at a sustained rate of 250 GPM; these wells would likely require construction of an iron and manganese removal plant such as that in Beltz system;

(B) One well in the San Lorenzo River Alluvium near Harvey West park, also capable of producing at a sustained rate of 250 GPM.

The Thurber Lane wells and treatment plant would connect into the main distribution system in the northern portion of the Live Oak area and should assist in meeting peak demands in that area. The Harvey West well would likely divert directly into the Coast Pipeline for delivery to GHWTP.

As for the Beltz well system, an allowance of 10 percent was used for assumed down time on these wells.

7.8 ALTERNATIVE 6 - WASTEWATER RECLAMATION

The potential applications for re-use of treated wastewater are usually quite limited due to health and economic reasons. Only certain types of re-use are allowed and the cost of constructing transmission facilities to convey the treated wastewater to the point of use are usually prohibitive. Wastewater reclamation activities are regulated by the Regional Water Quality Control Board. The three different types of applications commonly identified as potential uses for reclaimed wastewater include agricultural irrigation, landscape irrigation, and recreational impoundments. For the SCWD system, the most likely application is for landscape irrigation.

Due the unique set of circumstances outlined below, there appears to be a viable and potentially cost-effective wastewater reclamation program available to the SCWD:

(1) The City of Scotts Valley ("Scotts Valley") currently treats sewage at its wastewater treatment plant (WWTP) then pumps it through a 12-inch diameter pipeline through the City of Santa Cruz to an ocean outfall. From Scotts Valley, this pipeline runs along Graham Hill Road before reaching Highway 1. There are two potential users of reclaimed wastewater along the pipeline route which currently use large quantities of potable water from the SCWD system for irrigation -- the Pasatiempo Golf Course and the Oddfellow Cemetery. Each of these potential users has expressed an interest or willingness to use reclaimed wastewater and are immediately adjacent to the Scotts Valley pipeline. Furthermore, the pipeline was constructed with "turnouts" to these two irrigation users in anticipation of a wastewater reclamation program. The golf course is also listed on Scotts Valley's permit as a potential point of use for reclaimed wastewater.

Based on discussions with the operations manager of the Scotts Valley plant, the WWTP could produce water of an acceptable quality for irrigation use. Advanced tertiary treatment works would have to be installed at the Scotts Valley WWTP to provide acceptable water quality for irrigation use at the golf course and cemetery. This additional treatment would consist of sand filter units with appurtenant piping and pumps.

(2) Scotts Valley will need to install a second parallel pipeline to transport the expected increase in sewage flows from new development. This pipeline is also likely to have a 12-inch diameter. With the availability of two parallel pipelines, one pipeline could serve as a transmission line for the reclaimed wastewater while the other line conveyed the remaining wastewater to the outfall. Because the new pipeline would essentially serve the same purpose as without the reclamation program, no cost should be allocated to the reclaimed water users. Therefore, in effect, the required transmission pipeline for reclaimed water, usually the most costly element of a wastewater reclamation program, will already be installed by Scotts Valley.

(3) The Scotts Valley Water District (SVWD) is currently pursuing a similar wastewater reclamation program in Scotts Valley. A reclaimed wastewater transmission line is being installed as part of the Scotts Valley Drive Project in anticipation of using the water on a proposed golf course and park in the northern end of Scotts Valley. This program could help reduce the unit cost of a potential joint program with SCWD.

(4) The Scotts Valley WWTP currently treats about 20 MG per month, which would provide adequate quantities for irrigation at the proposed points of use. Based on compilation of recent meter

records, the peak combined use for Pasatiempo Golf Course and the Oddfellow Cemetery is about 12 MG per month in summer.

(5) Because most of the irrigation demand is at night and most wastewater production is in the day, a sufficient amount of storage must be available for the program to work. Although Scotts Valley has reserved a site along Graham Hill Road for such a storage reservoir, the use of one of the SCWD's existing Pasatiempo tanks would appear to present a more cost-effective plan. The smaller Pasatiempo tank (0.30 MG) appears to be a suitable size.

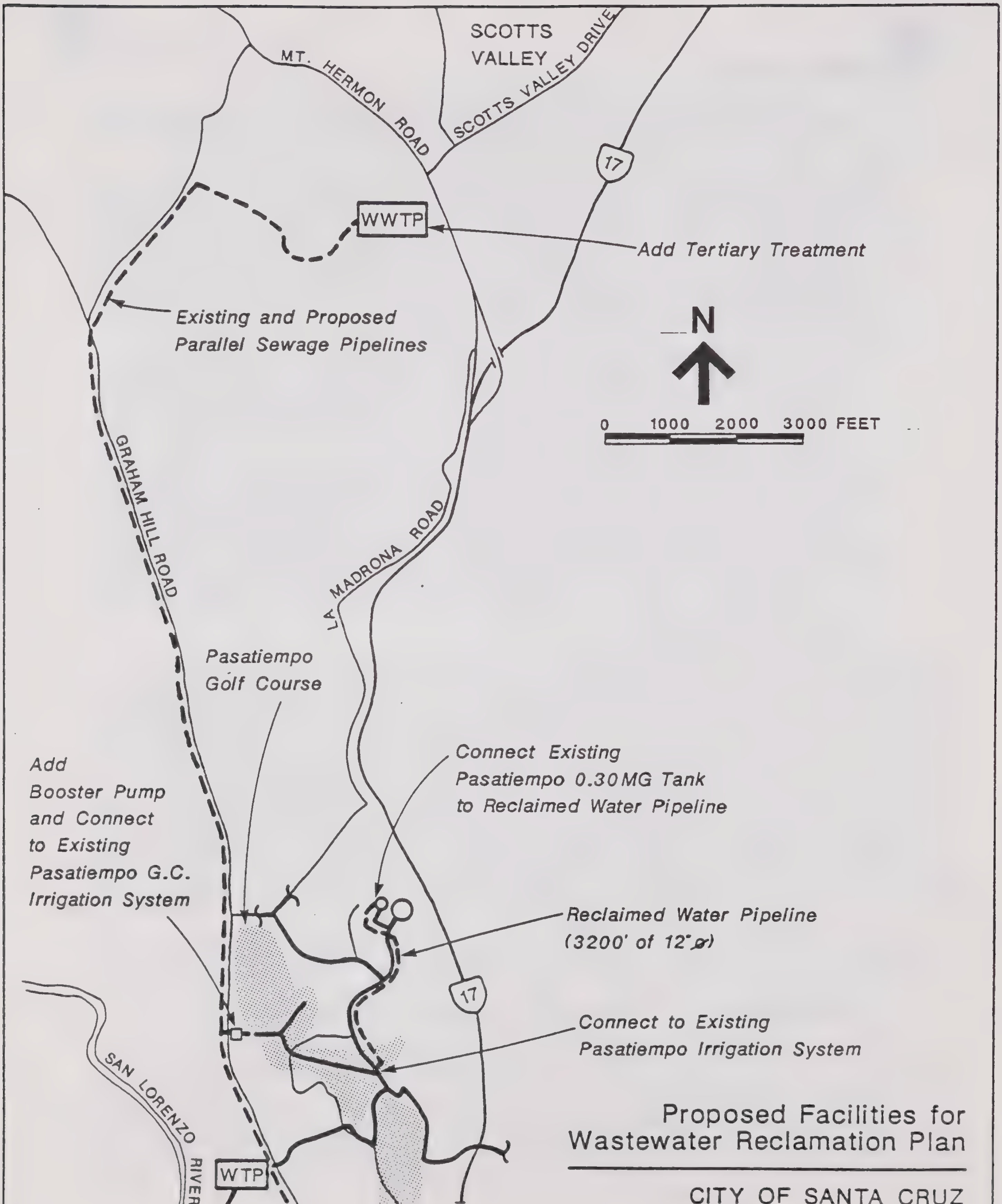
To implement the plan, the existing 0.30 MG tank would be physically disconnected from the SCWD distribution system and reconnected to the new reclaimed water pipeline as shown on Figure 7-2. However, a new, separate connection to the SCWD distribution system would also be installed to feed the tank "over the top" (i.e., with an air gap at the tank to prevent cross connection). In the winter, the minimal irrigation demands would be delivered to this tank through this connection to the SCWD distribution system since the irrigation demand would be insufficient to tie up use of the second wastewater pipeline. Because this tank would serve essentially the same purpose (i.e., providing regulation of local demands) as it currently does, the SCWD would not lose the use of this facility.

Although the above reasons appear to present a low-cost reclamation program, there is one potentially major drawback to this plan. Due to large potential cost savings, Scotts Valley is currently contemplating a plan whereby the existing WWTP would be shut down and only serve as a raw sewage pump station. All of Scotts Valley's <u>raw</u> sewage would be conveyed to the City of Santa Cruz's WWTP for treatment. Scotts Valley's share of the operation costs at the Santa Cruz WWTP may be significantly less than their current treatment cost due to economies of scale. If the Scotts Valley WWTP were to be shut down, the reclaimed wastewater users would have to pay the entire O&M cost of running the plant solely to produce reclaimed wastewater. This additional cost could render the wastewater reclamation program infeasible.

A schematic drawing of the proposed wastewater reclamation program is shown on Figure 7-2.

7.9 ALTERNATIVE 7A - ENLARGE LOCH LOMOND RESERVOIR BY 260 MG

The limited storage available in the SCWD system severely impacts the ability of the system to meet demands in critically dry years. Additional storage would be very effective in increasing the system's yield during drought periods. Rather than constructing new facilities, it is possible to expand the existing Loch Lomond Reservoir by raising the dam and spillway. Because of high natural runoff relative to the size of the reservoir (Loch Lomond spills frequently), the additional storage would be of value.



Proposed Facilities for Wastewater Reclamation Plan

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By constructing a 4-foot high parapet wall across the top of the dam and raising the crest elevation of the spillway by 4 feet to an elevation of 581 feet, an additional 260 MG of storage would be created to capture and store runoff in Loch Lomond Reservoir for later use. The parapet wall would be anchored into the top of the dam and could be supported by reinforced concrete buttresses. The increase in spillway crest elevation could be accomplished in a variety of ways, including a reinforced concrete wall as assumed in this study.

Before implementing such a plan, a number of potential obstacles would have to be evaluated. The SCWD current water rights for diversion and storage at Loch Lomond would have to be modified. Because many environmentalists and the State Department of Fish and Game are known to be displeased with the current 1 CFS release requirement, a strong protest to the SCWD's water rights can be expected. However, even if SCWD agrees to increase the fish release, this plan may still be effective.

In addition to the question of water rights, the structural integrity and flood control capability of the dam and spillway would have to be thoroughly analyzed in order to satisfy the State Division of Safety of Dams. The concession stand and recreational facilities at Loch Lomond may also need to be relocated to a higher elevation.

7.10 ALTERNATIVE 7B - ENLARGE LOCH LOMOND BY 1,010 MG

As explained above, additional storage would be very effective in increasing the yield of the SCWD water supply system. Under this alternative, the entire dam would be raised by about 14 feet to provide over 1000 MG of additional storage, a 35 percent increase in storage capacity. Although this plan would obviously be considerably more expensive than the previous alternative, the large increase in storage capacity may more than offset the increased cost. Despite the significant increase in storage capacity, there should be more than enough natural runoff to take full advantage of the additional storage. This alternative would also enhance the use of Felton Diversion by reducing spills.

The same disadvantages described under Alternative 7A are also present in this alternative, but likely to a greater degree. In particular, the impact on downstream flows and the safety of the dam under the increased loading must be carefully evaluated.

7.11 ALTERNATIVE 8A - SCOTTS VALLEY INTERTIE

Although the surface water diversions operated by SCWD are capable of producing large quantities of water on an annual basis, the SCWD system is vulnerable to severe droughts because of the extreme seasonal variations in surface flows and the relative lack of reservoir storage to store winter and

spring runoff. A conjunctive use program, whereby excess winter flows are stored for later use, would be of great benefit to the SCWD system.

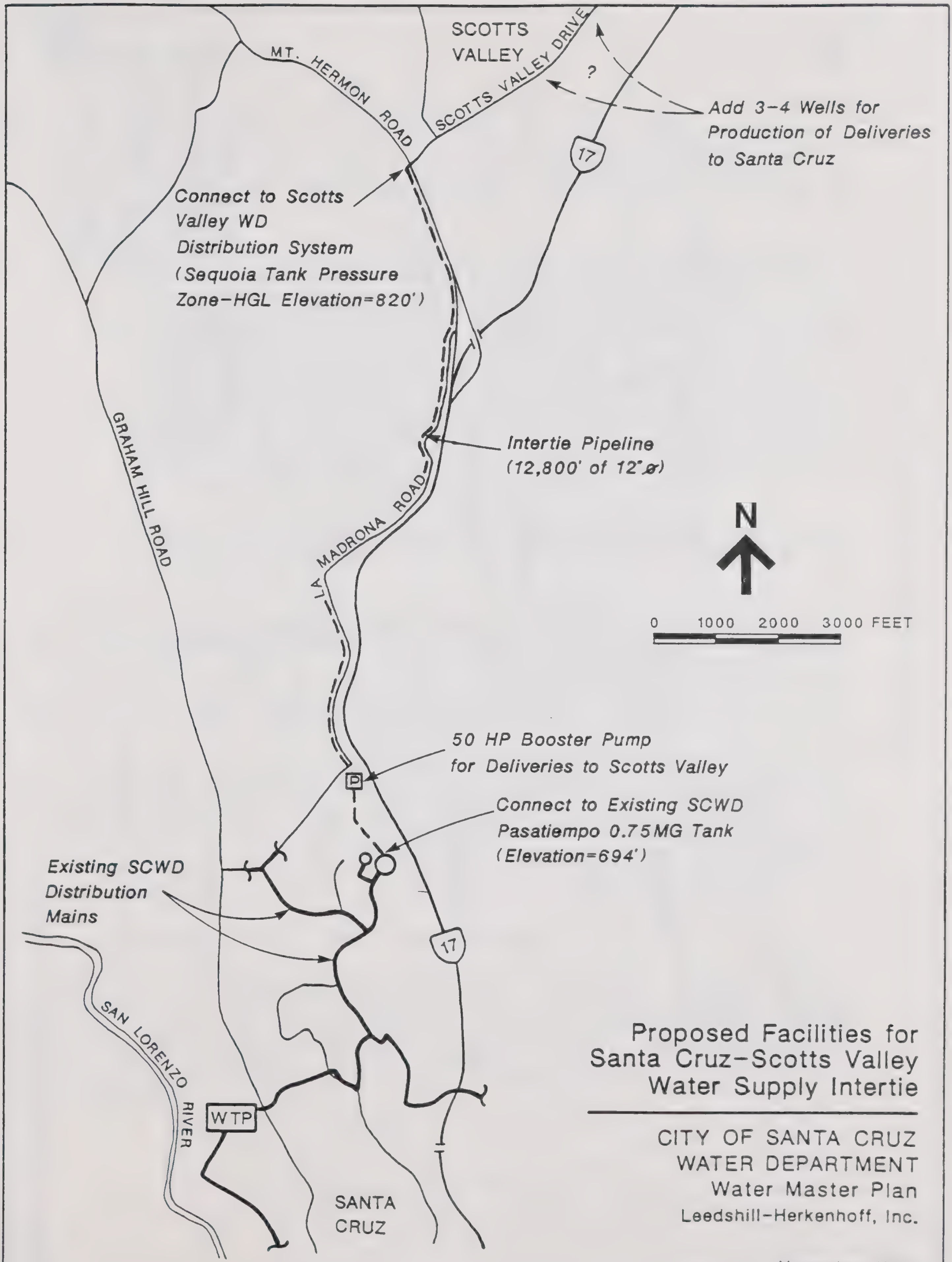
In this water supply alternative, a conjunctive use intertie program with the Scotts Valley Water District (SVWD) is proposed. Under this plan, SCWD would treat and deliver excess surface flows in the winter and spring months to SVWD on a regular basis. In return, SVWD would pump and deliver a large quantity of water to SCWD to alleviate potential supply deficiencies in a severe drought such as 1976-77. In effect, SCWD would "bank" water in the Scotts Valley groundwater basin by "in-lieu" deliveries of treated surface water. The required facilities, including a 12,800-foot, 12-inch diameter pipeline, are shown on Figure 7-3. This plan is similar to the intertie proposal studied in the COUNTY MP.

This intertie plan is considered to be a viable water supply alternative for the following reasons:

(1) Scotts Valley's water demands are currently met by groundwater pumping from the underlying aquifer system consisting of the Santa Margarita, Monterey, and Lompico formations. A schematic cross-section of the Scotts Valley groundwater basin is shown as Figure 7-4. The Scotts Valley Water Resources Management Plan Report (Todd, 1988) and discussions with the SVWD's groundwater consultants revealed that the Santa Margarita formation provides over 43,000 acre-feet of groundwater storage while <u>limited</u> portions of the Monterey and Lompico formations provide an additional 6800 acre-feet. Much larger volumes of groundwater storage are believed to exist in these formations but have not been thoroughly investigated. <u>Therefore, adequate volumes of storage for regulating a conjunctive use program may be available in the Scotts Valley aquifer system</u>.

(2) In the aforementioned report, the firm or "perennial" yield of the basin was estimated at 4200 acre-feet per year (AF/YR) based on a hydrologic balance analysis. The existing total pumpage is only 2500 AF/YR and a significant portion is recycled to the basin through irrigation. The net consumptive use is less than 2000 AF/YR. Additional growth in the Scotts Valley is expected to increase total demand by about 1000 AF/YR. <u>Therefore, even after future development, it would appear that the groundwater basin would not be fully utilized</u>.

(3) The SVWD and SCWD water systems are in close proximity to one another and provide favorable hydraulic conditions for the intertie. As shown on Figure 7-3, the intertie pipeline would connect the SCWD's large, existing storage tank at Pasatiempo with the SCWD's main Sequoia pressure zone. The locations of these interconnects would allow transfer of large quantities of water in either direction, particularly for diversions toward SCWD where



Proposed Facilities for
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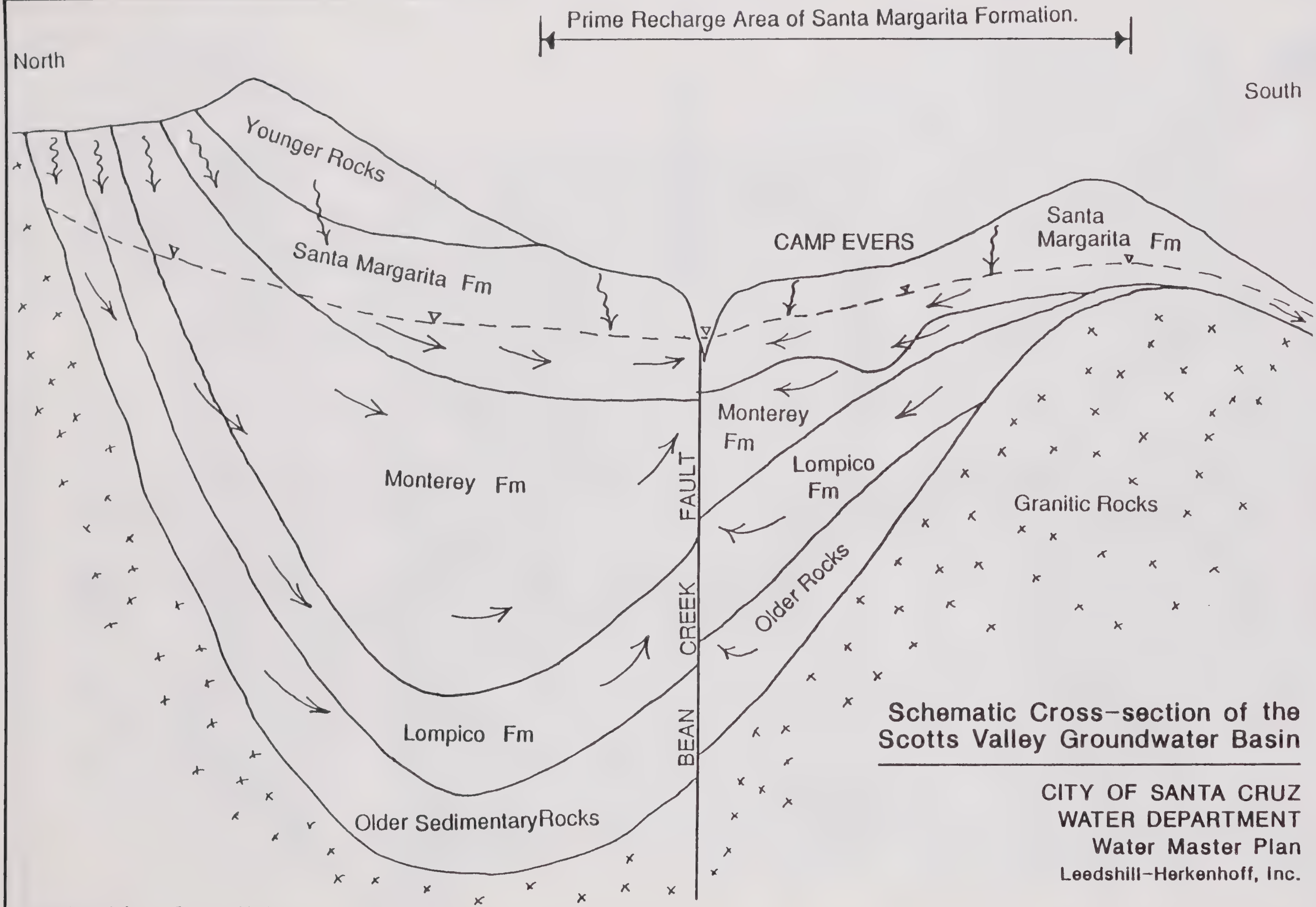

Schematic Cross-section of the Scotts Valley Groundwater Basin

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FIGURE 7-4

higher flow rates would be needed. Because the HGL in the Sequoia zone is about 126 feet above the Pasatiempo tank, no additional pumping would be needed for deliveries to Santa Cruz. Water would be distributed by gravity from the Pasatiempo tank throughout the SCWD service area. Some additional distribution piping may be necessary.

(4) While the delivery of water into the SCWD system during drought periods is an obvious benefit to SCWD, the benefits to SVWD are not as apparent but may still be considerable. By having direct access to a large system with treated surface water, the proposed intertie would provide a high level of reliability to the SVWD system. Potential contaminations of the groundwater basin, whether localized or regional, would not be completely disastrous. Also, localized problems with shallow domestic wells or groundwater quality problems could be alleviated. Additional "standby" wells for deliveries to Santa Cruz would provide a considerable amount of redundancy under normal conditions. Finally, SVWD's costs for supply production may be reduced.

(5) Through discussions with key individuals, SVWD has indicated an interest and willingness to cooperate with the SCWD on this proposed intertie.

For purposes of this study, it has been assumed that SCWD will deliver 20 MG/month to SCWD during the months of November to May in all but drought years. In return, SCWD will receive 70 MG/month in the months of April to October during critical drought years such as 1977. Each of these monthly delivery rates are possible under the plan developed in this study but would have to be negotiated prior to implementation.

Although there are some favorable conditions, many institutional, political, and environmental issues would first have to be resolved before implementing the plan. In particular, the amount of water which SCWD would be entitled to receive during critical droughts would be subject to extensive evaluation and negotiation. A detailed investigation of the groundwater basin would be needed to properly evaluate the feasibility of this plan. The impact on existing wells and the flow in Bean Creek would be of special concern.

7.12 ALTERNATIVE 8B - SOQUEL CREEK INTERTIE

A potential intertie between SCWD and Soquel Creek Water District (Soquel Creek WD) had been proposed previously and was examined in the COUNTY MP. However, after discussions with Soquel Creek WD representatives and consideration of alternative concepts, there appears be very limited potential for a conjunctive use intertie program between Soquel Creek WD and SCWD for the following reasons:

(1) In the northern end of its service area adjacent to the SCWD service area, Soquel WD relies exclusively on groundwater pumpage from the extensive Purisima formation. Unlike the Scotts Valley basin, the Purisima formation in Soquel does not provide a significant amount of storage. Due to the local hydrogeologic characteristics, groundwater in the Purisima formation is slowly moving through the aquifer. Therefore, reduced withdrawals from the basin under a conjunctive use plan as described would not necessarily save or store any water for future use. In effect, the Purisima formation is a very slow moving "river" which has little storage capability despite its relatively extensive size. Soquel Creek WD has implemented an extensive groundwater monitoring system which should provide additional insight into the storage capability of the Purisima formation.

(2) Unlike the Scotts Valley groundwater basin, future development in the Soquel area is expected to fully utilize the firm yield of the Purisima formation underlying the Soquel Creek WD. In fact, Soquel Creek WD has been planning major surface water projects on Soquel Creek in order to augment groundwater supplies in order to meet future demands. Therefore, there would appear to be little or no long-term excess yield or capacity in this aquifer system to utilize in a conjunctive use intertie program.

(3) Through discussions with Soquel Creek WD representatives, any conjunctive use or intertie program would have to provide <u>mutual</u> benefit to both agencies. Soquel Creek WD would request a <u>dependable</u> supply of water during the winter or spring months before agreeing to an intertie program. The SCWD system would not be able to guarantee a firm supply to Soquel in all years. Without a dependable intertie supply, Soquel Creek WD would have to continue building additional projects to meet demand and is concerned over adverse, irreversible impacts (e.g., saltwater intrusion). In other words, there would be no benefit to the district. Although an intertie would provide some additional reliability, such advantages are relatively insignificant to the larger Soquel Creek WD system.

(4) The hydraulics and geographical layout of the two water systems are not nearly as favorable as for Scotts Valley. A lengthy, costly transmission pipeline, booster pump station, and, possibly, a regulating reservoir would be needed to convey water back and forth. Because the interconnection would likely be near the main distribution systems of each agency, the service pressures in these regions could be adversely affected.

7.13 ALTERNATIVE 9 - DIRECT DIVERSION ON ZAYANTE CREEK

Because of its relatively high annual runoff, Zayante Creek was considered as a possible source of water for the SCWD by means of a direct stream diversion. A facility similar (but smaller) to that at Tait Street or Felton would be constructed near the proposed dam site or on the lower reaches of Zayante Creek.

The diversions from Zayante Creek could be made directly to the GHWTP via a connection to the existing Newell Creek Pipeline in the vicinity of Ben Lomond or Felton. Alternatively, diversions could be made directly into Loch Lomond Reservoir through a new pipeline and pump station near Lompico or through a connection to the Newell Creek Pipeline.

Because of high release requirements anticipated for fisheries as suggested in the COUNTY MP, the amount of flow available for diversion from Zayante Creek will be limited.

7.14 ALTERNATIVE 10 - PARALLEL COAST PIPELINE

To increase the hydraulic capacity of the North Coast supply system, parallel pipelines could be constructed in lieu of or in addition to the pump stations described under Alternative 3. This alternative would function in essentially the same manner as Alternative 3.

The existing 16-inch diameter pipeline between Majors and Laguna Creek is considered to be the "bottleneck" in the system as head losses under maximum flows are estimated to be about 10 feet per thousand feet of pipeline, well above the standard 3 to 4 feet per thousand generally used in the conceptual design of water pipelines. The supply lines from Liddell Spring and Laguna Creek above the "Y" are also somewhat undersized. However, open standpipes along the pipelines between Laguna and Liddell and the ocean limit the HGL and, thus, will prevent higher rates of flow unless these portions are replaced or paralleled. If the Coast pipeline between Majors and Laguna is paralleled, a 16-inch diameter pipeline should be used.

The remainder of the Coast Pipeline below Majors Creek appears to be adequately sized as head losses have been calculated to be less than 4 feet per thousand feet of pipe length.

7.15 ALTERNATIVES 11 AND 12 - DAM AND RESERVOIR ALTERNATIVES

7.15.1 General

As discussed throughout this report, the major weakness in the SCWD supply system is the relatively small amount of seasonal storage available for impoundment of surface water from winter and spring rainfall. Therefore, water supply alternatives involving construction of major new storage reservoir were an obvious addition to the list of alternatives to be evaluated.

Because of the considerable amount of field work and analysis required, comprehensive siting and environmental impact analyses were not included in the scope of work and budget for this study. However, several alternative reservoir sites were investigated for their water supply potential. A detailed analysis of all environmental impacts would be necessary if a feasible plan was identified and approved by the City Council.

About 20 possible reservoir sites were identified and reviewed in this study. These sites were selected from careful review of topographic maps as well as previous studies such as the COUNTY MP and an in-depth study conducted by the State in 1953. Numerous damsites on the western (coastal) side of the Ben Lomond Mountain drainage divide were identified. Within the San Lorenzo River watershed, the western slope is relatively steep and presented no apparent damsites. However, several damsites on the eastern side of the watershed were identified.

Based on an anticipated supply deficiency of 40 percent or 2000 MG, storage capacities on the order of 6,000 to 10,000 acre-feet were considered appropriate for the proposed reservoir. It should be noted that the actual instream release requirements for each site could significantly affect this assumed storage capacity. Several of these sites were considered to be infeasible due to the required transmission distance (e.g., Ano Nuevo, Waddell, and Scott Creeks) or incompatible sites for the required reservoir size (e.g., San Vicente, Liddell, and Kings Creeks).

After the initial review, the comparison data shown on Table 7-2 were compiled for seven representative sites. The information listed in this table allow a quick comparison between the key attributes of the seven selected sites. Of particular significance from a cost standpoint are the unit embankment quantities (indicator of cost per unit of storage), peak spillway discharge, and the distance to the SCWD production system. Because Zayante Creek Dam was not to be evaluated in this study, it was not considered for further study. Due to Soquel Creek WD's plans for water supply development on Soquel Creek, Glenwood Dam was ruled out for political and institutional concerns. The possibility of a joint venture on the Glenwood Project was not evaluated in this study. The Jamison site on Boulder Creek was ruled out because of upstream development which would have been inundated by the reservoir. Finally, after closer evaluation, the Bear Creek site was removed from further consideration due to its relatively large size which is not compatible with the SCWD's needs.

Three sites listed on Table 7-2 were chosen as the most desirable locations from a water supply viewpoint (cost, size, and yield). Because detailed feasibility studies have not been conducted as part of this work, these damsites have only been considered for the purposes of estimating the potential cost and determining the overall feasibility of a major water supply reservoir. Numerous additional engineering and environmental studies would have to be undertaken to determine accurate, comprehensive cost estimates.

Table 7-2

City of Santa Cruz Water Department
Water Master Plan

POTENTIAL RESERVOIR SITES

Stream/Location	Drainage Area (SQ MI)	Mean Annual Inflow (AF/YR) 1/	Reservoir Size (AF)	Embankment (CY/AF)	Maximum WSEL (FEET)	Peak Spillway Discharge (CFS) 2/	Distance to SCWD System (MILES)	Fisheries Habitat 3/
Bald Mountain School Dam on Laguna Creek	5.8	3,560	7,300	95	680	6,200	0.5	Steelhead Lagoonal
Baldwin Dam on Baldwin Creek	2.3	1,370	7,400	110	462	N/A	6	Steelhead Lagoonal
Glenwood Dam on West Branch of Soquel Creek	7.8	10,220	11,800	60	568	8,100	11	Steelhead Possibly Silver Salmon
Jamison Dam on Boulder Creek	7.5	13,580	5,900	50	840	7,500	14	Not given
Waterman Gap Dam on San Lorenzo River	6.5	4,420	8,400	55	885	6,800	18	Steelhead Silver Salmon (partial)
Zavante Dam on Zavante Creek	9.5	8,060	6,900	60	603	8,900	9	Steelhead Silver Salmon
Bear Creek Dam on Bear Creek	11.7	16,890	8,500	155	861	900	15	Not given

1/ Estimated mean annual discharge for 1921-82 from County Master Plan, Task Report B-2.
2/ From DWR, Bulletin 5, 1952.
3/ From County Master Plan, Task Report B-3. All reservoirs would have flushing and episodic sediment flow requirements.

FILE: DAM-INFO: DISK: F796-03-JMK-41

Each of the damsites listed on Table 7-2 is assumed to be suitable for a zoned earthfill dam with impervious core. Two of these sites, at Bald Mountain School on Laguna Creek and on the lower end of Baldwin Creek, would function in a similar manner and, thus are classified together as Alternative 11. The remaining site at Waterman Gap on the upper San Lorenzo River is evaluated as Alternative 12. There are other sites in the San Lorenzo River watershed which would function similarly to the Waterman Gap site, but their cost is believed to be significantly greater.

7.15.2 Alternative 11 - North Coast Reservoir

The Bald Mountain School Damsite is located approximately one mile downstream from the SCWD's existing diversion structure on Laguna Creek and just northwest of Bald Mountain School. The dam would be constructed at a streambed elevation of about 490 feet and a dam crest of about 690 feet, for a total height of about 200 feet to provide 7,300 acre-feet of storage. Since the SCWD's Laguna Creek Diversion is at an elevation of 623 feet, the diversion facilities and pipeline would have to be removed and relocated. The potential impacts on the SCWD's water rights for Laguna Creek, as well as the costs for removing and relocating the facilities, are difficult to project but could be severe.

The Baldwin Creek damsite, although apparently more costly than the Bald Mountain site, appears to be the preferred alternative for a North Coast Reservoir. A reservoir at the Baldwin Creek site, approximately 7000 feet upstream of the ocean, could essentially serve as an off-stream storage project to store diversions from the SCWD's North Coast water supply system in addition to natural runoff from the Baldwin Creek Watershed. Furthermore, only a short reach of pipeline would be needed to connect the reservoir to the SCWD supply system (i.e., the Coast Pipeline). Because Baldwin Creek is downstream of the 16-inch "bottleneck" in the Coast Pipeline, the existing conveyance system would probably be adequate to transport reservoir releases to the GHWTP. The possibility of releasing water into the stream below the dam for subsequent diversion at the Coast pipeline may improve fisheries habitat along the stream.

Baldwin Creek Dam would be built at a streambed elevation of about 240 feet and would be about 220 feet in height in order to provide 7,400 acre-feet of storage.

7.15.3 Alternative 12 - Upper San Lorenzo River Reservoir

The term "Upper San Lorenzo River" was used to describe this alternative since other damsites on Love Creek, Bear Creek, or Kings Creek could provide the required storage in the upper reaches of the San Lorenzo River and may be more desirable for other reasons not investigated in this study. However, the Waterman Gap site appears to be the most cost-effective site from a construction standpoint despite the fact that Highway 9 would have to be relocated and possibly bridged across the reservoir. The Waterman Gap

damsite is located on the extreme upper end of the San Lorenzo River, approximately 6 miles north of Boulder Creek.

The dam at the Waterman Gap site would be constructed at a streambed elevation of about 710 feet with a total height of about 150 feet to provide 6500 acre-feet of storage. Because the site is about 18 miles from Santa Cruz, the high cost of constructing a transmission pipeline would be prohibitive. However, under the conceptual plan developed in this study, the natural channel of the San Lorenzo River could be used for conveyance to the SCWD's existing Felton Diversion and/or Tait Street Diversion. As opposed to other alternatives, the SCWD's existing water rights for these two diversions would probably not have to be modified. However, water rights for the new reservoir would need to be obtained.

With use of the river for conveyance, this alternative would have no cost for transmission facilities. However, the infiltration losses and existing water diversions along the 18 miles of channel between the dam and Santa Cruz would have to be investigated to determine the associated impact on reservoir releases. Infiltration losses and "illegal" upstream diversions could significantly reduce the amount of flow reaching Santa Cruz. In such a case, a much larger reservoir may need to be built to deliver the required streamflow to the SCWD's San Lorenzo River diversion facilities. A damsite on Love Creek could significantly reduce the channel losses and water diversions if they are found to be significant.

7.16 COMBINED ALTERNATIVES

Various combinations of the above alternatives could be implemented if determined to be cost-effective. Most of the alternatives are compatible in that one would not significantly affect the feasibility of others. However, there are some exceptions, primarily if a major new storage reservoir is constructed. In that event, consideration of additional, major water supply alternatives may not be necessary, at least for another ten years. Also, Alternatives 3 and 10 would probably not be built together unless a major increase in capacity was determined to be effective.

Because the water supply yield resulting from the combined alternatives is not equal to the sum of the individual yields, a separate analysis is required for each combination.

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Chapter 8

EVALUATION OF WATER SUPPLY ALTERNATIVES

8.1 GENERAL

In this chapter, the water supply alternatives presented in Chapter 7 are evaluated based on selected evaluation criteria, including the impact on the capability of the SCWD water supply system to meet future demands in drought periods. Due to the relatively complex arrangement of water supply sources and facilities in the SCWD system, a computer simulation model is critical to an accurate determination of the system's ability to meet future demands (i.e., its "yield").

A detailed, comprehensive computer model was developed to simulate operation of the entire SCWD water supply system over time for each of the proposed water supply alternatives. As defined in this study, the SCWD water supply system is comprised of all stream diversions from the North Coast and San Lorenzo River (SLR), raw (untreated) water transmission pipelines, booster pump stations, groundwater wells, Loch Lomond Reservoir, Graham Hill Water Treatment Plant (GHWTP), and Beltz WTP. Bay Street Reservoir is considered part of the distribution system, which is described in Chapter 3.

The evaluation process used in this study is described in the remaining sections of this chapter. Following a list of the evaluation criteria, the development and use of the Operations Model developed for this study is explained in Section 8.3. <u>A clear understanding of the explanations provided in Section 8.3, particularly the difference between the firm yield and "operational yield" computation modes, is essential to proper interpretation of the results presented in Section 8.4</u>. Following the description of the Operations Model, the results of the operations studies, the potential environmental impacts, and the estimated costs are then presented. Using this information, evaluations of each water supply alternative are presented in Section 8.7. This chapter concludes with a section on several special analyses which were conducted to clarify and support the findings of this study.

8.2 EVALUATION CRITERIA

Each of the water supply alternatives identified in Chapter 7 were evaluated in relation to Alternative 1, which represents the existing water supply system with certain required or desired upgrades as described in Section 7.2. The feasibility of each alternative was evaluated according to its impacts on the following factors:

- Yield of Supply System
- Water Quality
- Potential Environmental Impacts
- Construction and O&M costs

The ability of the SCWD water supply system to meet future demands (i.e., its "yield") was analyzed with a comprehensive Operations Model prepared for use in this study.

8.3 OPERATIONS MODEL OF WATER SUPPLY SYSTEM

To aid in the evaluation of each of the proposed water supply alternatives, a detailed, comprehensive computer model was developed to simulate operation of the SCWD water supply system under a wide range of conditions. This model was used to "operate" the water supply system over the historical hydrologic conditions for the 1921-1986 period (as was done in the COUNTY MP study) using the facilities proposed for each water supply alternative described in Chapter 7. In other words, the model evaluates how the <u>future</u> water system, with alternative improvements, will perform under projected <u>future</u> demands under the <u>historical</u> hydrologic conditions which have occurred. Although future hydrologic conditions (e.g., rainfall, streamflow, etc.) will obviously not occur in the precise sequence and magnitudes as have occurred historically, recorded measurements of hydrologic conditions over such an extensive period (66 years) should be highly representative of the expected hydrologic conditions in the future.

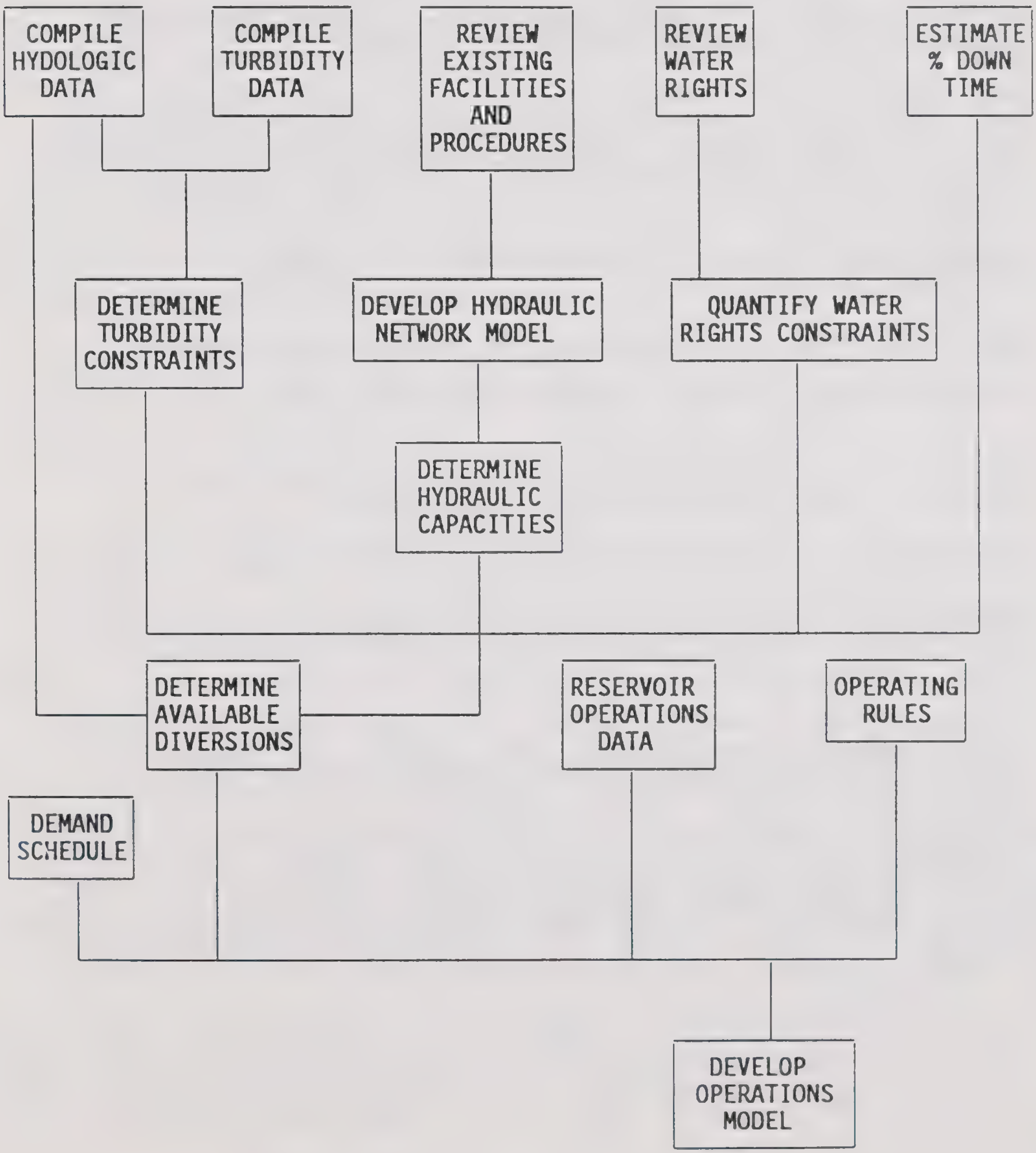
The development of the Operations Model, which produces the primary results used in evaluating the water supply alternatives, is discussed in the following subsections. A more detailed explanation is presented in Appendix E, bound separately. <u>In essence, the model is used to determine the anticipated frequency and magnitude of supply deficiencies for the various water supply alternatives</u>.

8.3.1 Development of Operations Model

The operations model of the SCWD supply system includes consideration of all factors affecting the system's ability to meet future demands based on specified hydrologic data. Input data for the model consisted of a wide variety of hydrologic and hydraulic information, most of which was developed as part of this study. Figure 8-1 shows a schematic diagram of the approach used in the development of the Operations Model. As indicated above, a detailed description of the development of the operations model and sample output from the computer model are included in Appendix E to this report.

City of Santa Cruz Water Department
Water Master Plan

DEVELOPMENT OF OPERATIONS MODEL



The following list summarizes the elements that were considered in development of the Operations Model:

- Under operational yield mode (see Section 8.3.3), projected monthly demands in the SCWD service area for the year 2005 high growth scenario described in Chapter 2 (total annual demand of 5175 MG), including fluctuations due to monthly and seasonal variations in climate;

- Required reductions in water demands due to water conservation as determined from the procedure explained in Section 8.3.6.;

- Total runoff at each streamflow diversion adjusted to "available diversions" by including limitations due to water rights, hydraulic capacities of pumps and pipelines, excessive turbidity during rainy periods, and "down times" (percentage of time a facility is assumed to be inoperable);

- Seepage losses between the streamflow gage at SLR at Big Trees and the Tait Street Diversion;

- Hydraulic interactions between the Coast and SLR Pump Stations;

- Available production capacity from the Beltz well system;

- Operating rules to determine when to use Tait Wells and/or Loch Lomond Reservoir during periods of excessive turbidity in surface runoff which renders the North Coast and SLR sources inoperable;

- Operating rules to determine if diversions should be made from Felton;

- Operating rules to determine the priority of use for all sources (i.e., which source is used first, second, etc. under various conditions); and

- All elements of the water balance at Loch Lomond Reservoir including storage changes, natural inflows, precipitation, evaporation losses, fish releases, diversions from Felton, releases to SCWD, and spills.

As noted above, the Operations Model of the SCWD supply system also uses a set of proposed operating rules which prescribe the order in which the sources are to be used to meet monthly demands and whether Felton Diversion should be operated or not. For the winter and early spring months with low water demands, all of the sources will not be required, even under the future demands. In general, the existing sources were used in the following order:

1. North Coast
2. SLR - both surface diversion and Tait wells
3. Beltz Wells
4. Loch Lomond Reservoir

In instances where Loch Lomond is nearly full in the late spring months, reservoir withdrawals should be used prior to the SLR-Tait Street diversion or Beltz Wells (see Section 8.3.4). The proposed operating rules recommended for use in the SCWD supply system are presented in Section 8.3.4. A detailed description of the development of these rules is also presented in Appendix E.

The same operating rules were utilized in all evaluations of water supply alternatives. Although these rules theoretically should be adjusted slightly for each alternative, the relative impacts of such adjustments would be negligible since the operating rules were found to be relatively insensitive with regard to the water supply alternatives examined. Appropriate adjustments to the rules were made, however, to include increases in operational storage at Loch Lomond for Alternatives 7A and 7B.

The Operations Model was designed to operate in two different modes -- the "firm yield" and "operational yield" modes. The methodologies used and reasoning behind the firm yield and operational yield computation modes are described in the following sections.

8.3.2 Firm Yield Mode

In the firm yield mode, the model was used to compute the firm or "safe" annual yield of the SCWD supply system. Firm or safe yield is defined as the maximum average annual water demand that can be met by the system in <u>all</u> years without incurring any water supply deficiencies. The firm yield was determined by iteratively varying the annual demand until all of the available storage at Loch Lomond would be used by the end of the critical drought (October 1977).

<u>A firm yield analysis is not representative of actual operations</u>, but is a commonly used, theoretical indicator of the maximum amount of annual demand that can be supplied by each alternative without any restrictions in water use. This method of estimating the system yield provides a convenient indicator of dry-year yield, <u>but is based entirely on the conditions prevailing in the single worst dry period used in the analysis</u> (in this instance, 1976-77). Therefore, the overall performance of the system in other dry years is not evaluated by this method.

If adequate, low-cost water sources are available, water supply systems are often designed to provide a firm yield equal to or greater than the anticipated annual demand. However, many water utilities in California are now recognizing that the cost of developing and maintaining a firm yield at or above the average annual demand is no longer practical from an economic

standpoint. Because the best water sources have already been developed and the regulatory climate makes development of new supplies extremely difficult and costly, many agencies are now relying on "demand management" (i.e., water conservation) to balance available supplies during infrequent drought periods. Because demand management may be an effective alternative for the SCWD, an "operational yield" analysis was deemed necessary.

8.3.3 Operational Yield Mode

For the operational yield mode, the model was used to simulate operation of the supply system under the projected demand for year 2005 under the high growth scenario (see Chapter 2) rather than solving for the demand as in the firm yield mode. In the operational yield mode, the Operations Model is used to determine the extent of required demand reductions (i.e., water conservation), if any, to eliminate the water supply deficiencies at a given demand level. This method of evaluating system performance quantifies the number and magnitude of supply deficiencies for all dry periods in the analysis period. Because both the frequency and magnitude of the demand reductions are important in evaluating the overall performance of each alternative, more emphasis should be given to the results of the operational yield analyses than to the firm yield analyses. In essence, the operational yield mode represents actual water system operations. The methodology used to determine the extent of required conservation in drought years is described in the next section.

8.3.4 Operating Rules

As noted previously, the Operations Model incorporated several operating rules to prioritize use of the available water supply sources. These rules are needed to methodically prescribe which source should be used to obtain maximum or optimal use of the available sources and facilities. Based on the hydrologic period used in this study, a set of operating rules proposed for use by the SCWD was developed to provide optimal use of all sources in consideration of system yield, cost, and water quality, and environmental effects. These rules were incorporated into the Operations Model and, hence, have been used in the evaluations of water supply alternatives.

The following sections briefly describe the principles used to develop the operating rules. More detailed information on these rules is provided in Appendix E and the specially prepared Operations Manual, both of which are bound separately.

(1) Priority of Use - Because it offers the best water quality and the lowest unit production cost, the North Coast sources should always be used first and to the greatest extent possible. In most situations, the SLR-Tait Street diversion should be used next in order to preserve the valuable storage at Loch Lomond Reservoir, which is critical to safeguarding the drought year yield of the system. Although production from the Newell Creek system offers better

water quality and a lower unit cost than the SLR source, use of reservoir withdrawals before use of the SLR source should be restricted to winter or spring months when the reservoir is spilling or nearly full. Use of the reservior during fall and summer or at other times when the reservoir is relatively low is not prudent since there is no guarantee that the valuable reservoir supply will be replenished.

The cost savings and improvement in water quality achieved through more frequent use of the reservoir is considered to be insignificant in comparison to the severe adverse impact which such operation could have on the system's yield in the event of a drought. Furthermore, much of the cost savings attributed to greater use of the Newell Creek system is offset by additional energy costs at Felton Diversion since the lower reservoir levels will trigger increased use of Felton Diversion (see below).

Similar reasoning to that described above applies when deciding whether to operate Beltz wells or use reservoir withdrawals to meet the remaining demand after use of the other higher priority sources. Although use of Beltz wells before Loch Lomond Reservoir would reserve more water at the reservoir for safeguarding the drought year yield, the cost of producing groundwater from these wells is significantly higher than the comparable production cost for Loch Lomond supplies. However, as explained above, greater use of Loch Lomond Reservoir will impact the drought year or firm yield of the system and also increases the energy costs for Felton Diversion. Thus, a rule that balances system yield, production costs, and water quality is needed.

To illustrate the tradeoff between the impact on drought year yield and the savings in production costs, several alternative operating rules for use of the Beltz wells versus Loch Lomond Reservoir were analyzed. The decision whether or not to use the Beltz wells before Loch Lomond Reservoir under each of the rules was dependent on the time of year and storage level at Loch Lomond Reservoir. When the reservoir is relatively full for the time of year, withdrawals can be made to reduce production costs without signficantly impacting the firm yield. A comparison of the tradeoff between firm yield and cost differentials in production cost for the various alternative rules is shown in Table 8-1. As shown, the use of Loch Lomond Reservoir before Beltz wells under all conditions would decrease the firm yield by about 535 MG/YR with a corresponding decrease in average annual production costs of only about $20,000. Therefore, it can be concluded that use of the Beltz wells prior to withdrawals from Loch Lomond will provide a considerable increase in firm yield at an extremely low unit cost (about $40/MG).

Table 8-1

City of Santa Cruz Water Department
Water Master Plan

COMPARISON OF GROUNDWATER USE RULES

ALTERNATIVE OPERATING RULES	DECREASE IN FIRM YIELD (MG/YR)	AVERAGE ANNUAL USE LOCH LOMOND (MG/YR)	BELTZ WELLS (MG/YR)	FELTON DIVERSION (MG/YR)	AVERAGE COST SAVINGS ($/YR)
1. Always Use Groundwater Wells before Loch Lomond Reservoir.	0	1,057	401	297	0
2. Use Groundwater Wells before Loch Lomond Reservoir unless storage is greater than the following: October 2500 MG Nov-Feb 2300 MG March 2500 MG	0	1,077	380	301	1.600
3. Use Groundwater Wells before Loch Lomond Reservoir unless storage is greater than 2300 MG in October through May; Groundwater is used first for June through September.	70	1,092	365	306	2.400
4. Use Groundwater Wells before Loch Lomond Reservoir unless storage is greater than 1900 MG (all months).	185	1,282	173	383	9.600
5. Always Use Loch Lomond Reservoir before Groundwater Wells.	535	1,420	16	426	20.700

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Based on the above discussion and the results displayed in Table 8-1, it was decided that Loch Lomond Reservoir should be used before the SLR-Tait Street diversion or the Beltz wells only when the reservoir is nearly full or spilling in order to safeguard against potential droughts. The specific storage levels which define "nearly full" for each month are given in the Operations Manual. Because of its lower production cost and to preserve groundwater supplies, the SLR-Tait Street diversion should always be used before the Beltz wells.

(2) Felton Diversion Rule - Due to the high energy costs for operating Felton Diversion and the high probability of spill due to natural inflow (see Section 4.2.4), the SCWD has been faced with difficult decisions on whether or not to operate Felton Diversion. If the reservoir spills before the Felton Diversion water is actually needed, a considerable amount of energy (and cost) will be "wasted". However, use of Felton Diversion to augment natural runoff into the reservoir can provide valuable assistance in protecting the yield of the SCWD supply system during a severe drought. Therefore, to aid the SCWD in future operations, an operating rule based on the hydrologic study period was developed to prescribe when Felton Diversion should be operated.

The proposed Felton Diversion Operating Rule used in this study is shown in Figure 8-2. As indicated, this proposed rule is based on the storage level at Loch Lomond Reservoir and the seasonal rainfall to-date. If the point represented by the storage at Loch Lomond and the seasonal rainfall to-date is below the appropriate line for the current month, Felton Diversion should be operated if adequate flow is available in the SLR.

As is the case for the operating rule involving the Beltz wells (see Table 8-1), the decision to divert from Felton impacts both the firm yield of the system and production costs, and requires that a balance be made between the two. Unnecessary energy costs for pumping water from the Felton Diversion can be avoided if diversions are not made when the reservoir is likely to spill.

The sensitivity to various alternative operating rules for Felton Diversion was analyzed by comparing firm yield to the average annual diversion from Felton. As indicated by the results shown in Figure 8-3, a rule to always divert at Felton, regardless of reservoir levels and seasonal rainfall, results in an increase in firm yield of only 80 MG/YR compared to never using Felton Diversion, but requires an increase in average annual diversions (as well as associated pumping costs) of 220 MG/YR. Most of the large difference between increased firm yield and annual diversions from Felton is represented by increased spills at the reservoir. However, the operating rule selected for this study achieves a 65

FELTON DIVERSION OPERATING RULE

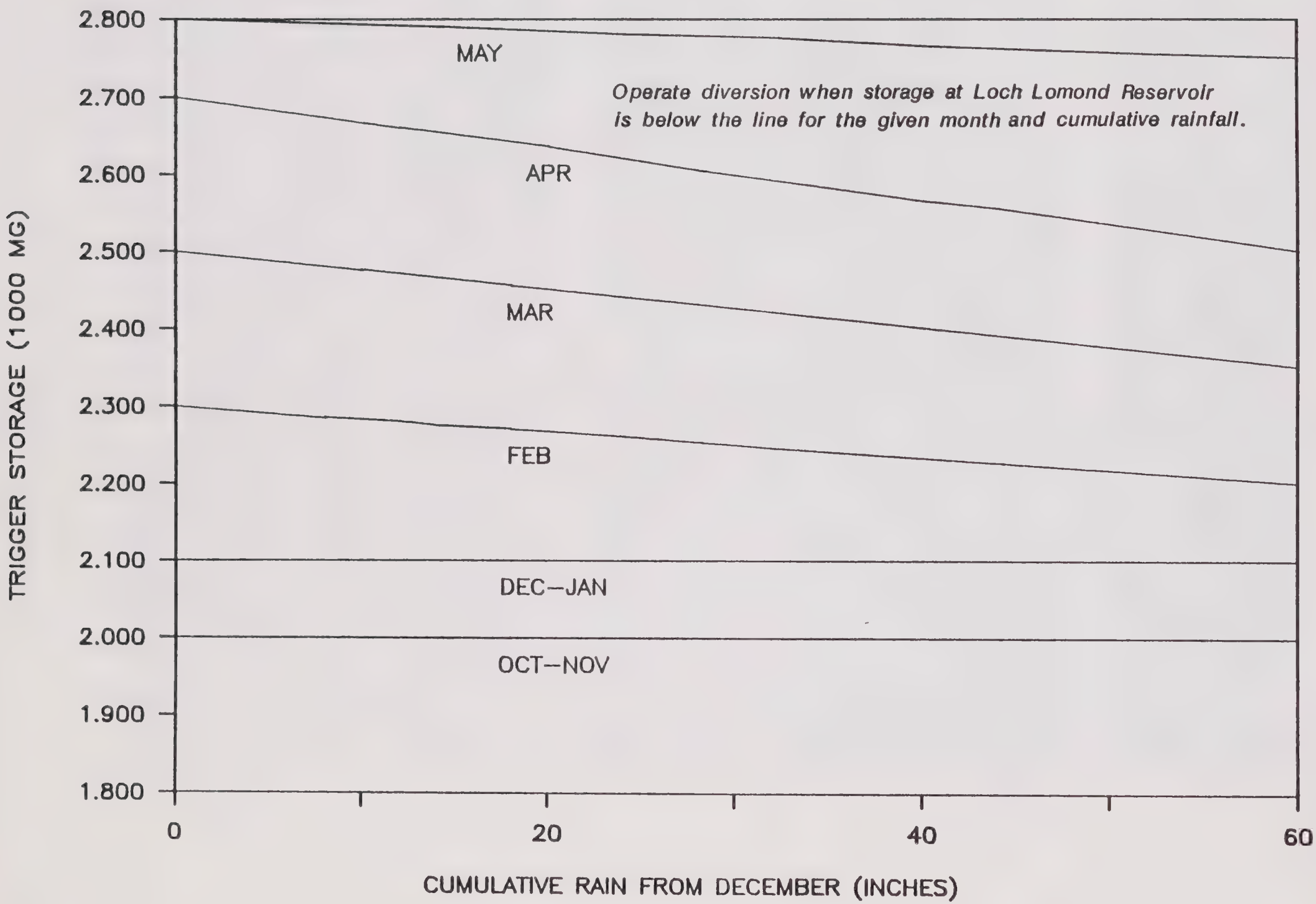


FIGURE 8-2

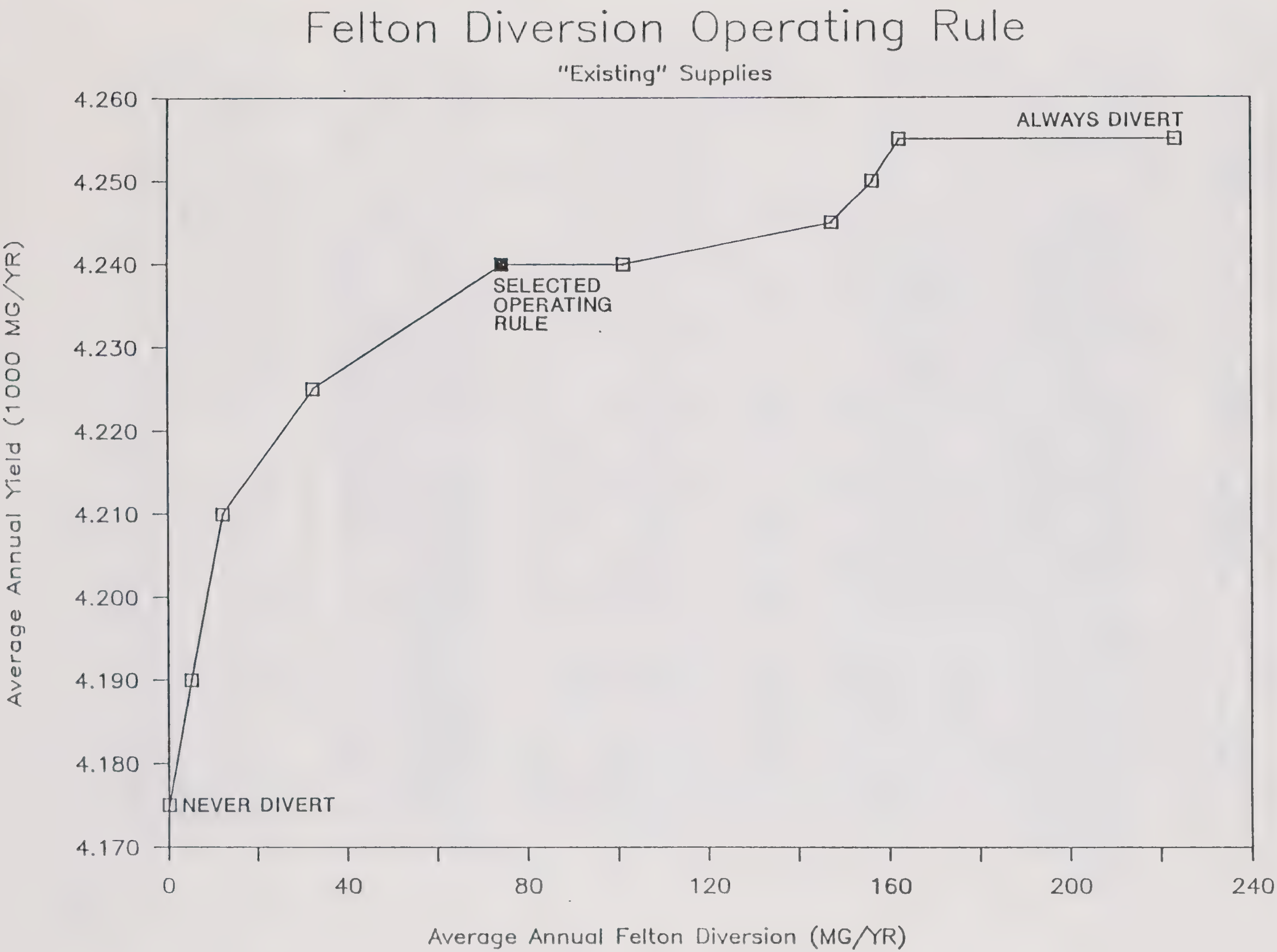

Felton Diversion Operating Rule
"Existing" Supplies
Average Annual Yield (1000 MG/YR)
4.260
4.250
4.240
4.230
4.220
4.210
4.200
4.190
4.180
4.170
ALWAYS DIVERT
SELECTED
OPERATING
RULE
NEVER DIVERT
0
40
80
120
160
200
240
Average Annual Felton Diversion (MG/YR)

FIGURE 8-3

MG/YR increase in firm yield, while only requiring average annual diversions of about 70 MG/YR. Therefore, the selected operating rule represents a near-optimal solution for the tradeoff between firm yield and production costs.

It should be noted that the results displayed in Figure 8-3 are entirely dependent on the specific conditions which occurred during the severe 1976-77 drought. During severe droughts when Felton Diversions is most sorely needed, there typically is little or no flow available in the SLR after consideration of fish releases. Because Loch Lomond Reservoir filled naturally in 1975 in the simulation model, Felton Diversion could only contribute to the firm yield during 1976 and 1977 when the SLR flows were very low. Therefore, Felton Diversion does not appear to significantly increase the firm yield of the supply system. However, based on the selected operating rule, the effective unit cost of this source is quite low, about $185/MG. During future droughts, Felton Diversion's impact on the system's firm yield may be considerably higher than the values shown in Figure 8-3.

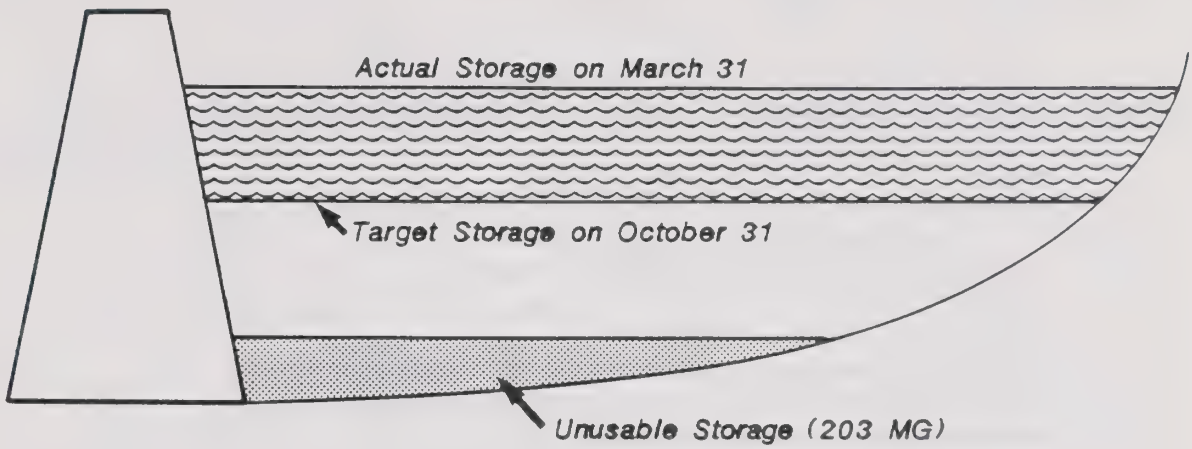
(3) <u>Loch Lomond Reservoir Operating Rule</u> - If an extremely dry winter is encountered, the SCWD is currently faced with a difficult decision on what percentage of the total available storage at Loch Lomond Reservoir should be used in the current year to avoid or minimize the need for water conservation measures. The total <u>available</u> storage is the total volume stored at Loch Lomond Reservoir less the storage not available for use by SCWD (unusable storage). The unusable storage consists of 102 MG reserved for possible use by the San Lorenzo Valley County Water District (per prior agreement) and about 100 MG of inactive storage below the lowest outlet. A possible decrease in available storage due to sediment deposition has not been evaluated in this study.

If a large percentage of the available storage at Loch Lomond is allocated for the current year and a second <u>critically dry</u> year occurs, huge reductions in water demand will be necessary through mandatory rationing of supplies in the second year. On the other hand, if only a small percentage of available storage is allocated for the current year, conservation would be less severe but would be required on a more frequent basis in order to maintain the large "reserve".

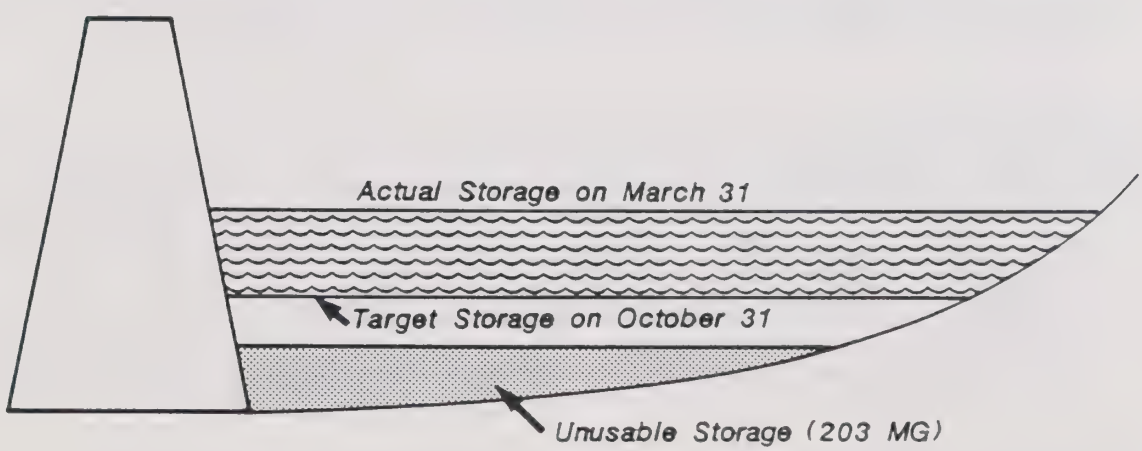
Based on a considerable amount of analysis of hydrologic data in critically dry years relative to projected water demands, a recommended operating rule or allocation procedure was developed to make this important decision. The proposed procedure is shown schematically in Figure 8-4. As indicated, in the first critically dry year (Year 1) when conservation may be needed, one-half of the usable storage should be allocated for use in the current

FIGURE 8-4

YEAR 1
Withdraw 1/2 of Usable Storage



YEAR 2
Withdraw 2/3 of Usable Storage



Loch Lomond Reservoir –
Storage Allocation for Drought Period

CITY OF SANTA CRUZ WATER DEPARTMENT
Water Master Plan
Leedshill-Herkenhoff, Inc.

year. In the second year of a severe drought, two-thirds of the usable storage should be allocated for use. If more than one-half of the usable storage was withdrawn in the first critically dry year, large demand reductions in the form of rationing would likely be needed if the drought persisted for a second year. In the second year (Year 2), at least two-thirds of the remaining storage should be allocated for use. This operating rule provides the proper balance between utilization of storage to minimize the frequency of supply deficiencies or need for conservation measures while still maintaining adequate reserves to prevent disastrous shortages in the event of a severe two-year drought.

As implied in the recommended operating rule, Loch Lomond should be operated to minimize the impacts of a two-year drought of the magnitude of the 1976-77 drought. Because of its relatively limited capacity, the reservoir is not suited to supply the demands of the SCWD system during droughts of longer duration and equivalent magnitude without imposing strict water use regulations or rationing. However, as discussed later in this chapter, the probability of a severe three-year drought period is extremely remote.

In order to assess whether a given year fits within the definition of "Year 1" or "Year 2" with regards to Loch Lomond operations, the flow measured at the San Lorenzo River at Big Trees gage (SLR) at the end of the previous August can be used as an indicator of the hydrologic conditions of the preceding year. Based on analysis of historical hydrologic data for dry years, a given year is assumed to be a second consective critically dry year only if the SLR gage has less than 14 CFS of flow on August 31 of the previous year.

On or about March 31 of a dry year, SCWD will assess the water supply situation for the upcoming peak use period using the procedure described in Section 8.3.5. If the river flow for the preceding August 31 is greater than 14 CFS, this would indicate that the <u>current</u> year would be the <u>first</u> year (Year 1) of a potential two-year severe drought. If less than 14 CFS was measured, the preceding year was assumed to have been critically dry, indicating that the current year is a <u>second</u> <u>consecutive</u> dry year (Year 2).

The Loch Lomond Reservoir operating rule described above is utilized in the calculation of the required conservation as described in the following subsection.

8.3.5 Calculation of Required Conservation

In the operational yield mode, analysis of the water supply alternatives in the Operations Model is an iterative process. The model is first run under the full future demand (year 2005, high growth scenario) and the results are

reviewed to identify those years in which the supply system cannot provide the entire demand. In such occurrences, defined as "supply deficiencies" in this study, the water demands must then be reduced to represent required implementation of water conservation measures.

To determine if conservation would be required in a given year, the sum of the "usable" storage (defined above) from Loch Lomond Reservoir and projected water production from all other sources is compared to the anticipated demand for the peak use period of April 1 through October 31. During all other months, supplies are generally sufficient to meet demands without use of Loch Lomond Reservoir, even in drought years. Therefore, April 1 through October 31 is considered the critical period for evaluating the system perfomance under drought conditions.

A sample of the calculations used in this study to determine the required level of demand reduction through conservation measures for various drought years is shown in Table 8-2. These calculations are based on rainfall quantities and various other hydrologic parameters as of the end of March for the given drought year when conservation may be necessary. Based on input of these values for a particular drought year, the level of required conservation, if any, for the upcoming April 1 through October 31 period of that year is computed.

The use of the calculation procedure shown in Table 8-2 is of fundamental importance in determining the overall performance of each water supply alternative. As such, the procedure developed in this study and shown on Table 8-2 is explained in detail in the following paragraphs. Following input of the required hydrologic data (Step 1), the remainder of the calculation is performed automatically in a LOTUS 1-2-3 spreadsheet.

SCWD will use this automated procedure in the future to assess the water supply situation whenever a dry winter occurs in order to determine whether conservation measures are necessary and, if so, to what extent. This program should be extremely valuable to the SCWD staff in obtaining a realistic assessment of the water supply situation in dry years.

The individual steps required to determine the need, if any, and extent of conservation measures for the SCWD supply system are as follows:

Step 1: Compile Hydrologic Data

Input to the calculation of the required conservation percentage includes the following historical data which are readily available from SCWD gages:

1. Total rainfall at Newell Creek Watershed for the previous Oct. 1 through Nov. 30 period;

Table 8-2

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CALCULATION OF CONSERVATION PERCENTAGES FOR APRIL-OCTOBER

WATER YEAR:	1976
HISTORICAL DATA:	
1. Total Rainfall for October 1-November 30:	7.06 inches
2. Total Rainfall for December 1-January 31:	1.04 inches
3. Total Rainfall for February 1-March 31:	5.32 inches
4. Loch Lomond Storage on March 31:	1,865 MG
5. Mean Daily Flow at SLR on August 31:	21.00 CFS
6. Minimum Mean Daily Flow at SLR for March:	18.00 CFS
APRIL 1 THROUGH OCTOBER 31 PROJECTIONS:	
7. Total SCWD Demand for April 1-October 31:	3,600 MG
8. Usable Loch Lomond Storage for March 31:	1,662 MG
9. Target Storage for October 31:	1,034 MG
APRIL 1 THROUGH OCTOBER 31 PRODUCTION PROJECTIONS:	
10. Allocation for Use at Loch Lomond:	831 MG
11. Natural Demand at Loch Lomond:	150 MG
12. Available Felton Diversion:	21 MG
13. Production from Other Sources:	2,201 MG
14. Production from Loch Lomond:	702 MG
15. Projected Storage for October 31:	1,034 MG
CONSERVATION:	
16. Unmet Demands:	697 MG
17. Average Conservation for April 1-October 31:	19%

MONTH	REDUCTION
April	5%
May	10%
June	23%
July	23%
August	23%
September	23%
October	23%

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2. Total rainfall at Newell Creek Watershed for the December 1 through January 31 period;

3. Total rainfall at Newell Creek Watershed for the February 1 through March 31 period;

4. Storage volume at Loch Lomond Reservoir on March 31;

5. Mean daily flow at the San Lorenzo River at Big Trees gage for the previous August 31;

6. Minimum mean daily flow at the San Lorenzo River at Big Trees gage for the month of March; and

7. The projected total SCWD water demand for the subsequent April 1 through October 31 period. (For the operational yield analyses in which the year 2005 high growth scenario was used, this demand was estimated to be 3600 MG).

Step 2: Determine Usable Storage from Loch Lomond Reservoir

After the program automatically determines whether the current year is the first or second consecutive critically dry year (i.e., Year 1 or 2) the maximum amount of water that should be used from Loch Lomond Reservoir is determined. First, the usable storage at Loch Lomond at the end of March (line 8 in the table) is computed as the storage volume at the end of March (line 4 above) less 203 MG of unusable storage for "dead" or inactive storage below the lowest outlet plus the entitlement of San Lorenzo Valley County Water District (SLVCWD). The corresponding allocation for use from Loch Lomond (line 11) is then determined by multiplying the usable storage by the appropriate percentage (50 percent for Year 1, 67 percent for Year 2).

As described below, the "allocation for use" quantity must then be reduced by the "natural" demand of the reservoir and increased by inflows from Felton Diversion to determine the maximum amount of water production from Loch Lomond for use in the SCWD service area during the April 1 through October 31 period.

Step 3: Determine "Natural" Demand

After the storage at Loch Lomond Reservoir is allocated, estimates of the inflows and outflows for the April 1 through October 31 period related to fish releases, natural inflow, and net evaporation are needed. The sum of these three components was termed as the "natural demand" at Loch Lomond Reservoir in Table 8-2 (line 11). Review of the historical data for dry years in the 1921-86 analysis period indicates that the natural demand at Loch Lomond Reservoir for drought years is about 150 MG or less for the April 1 through October 31 period.

Step 4: Determine Inflow from Felton Diversion

In addition to natural inflows, the anticipated inflows to the reservoir include any diversions that could be made from Felton Diversion from April 1 through May 31 (diversions in early months are already in storage and no diversions are allowed after May 31). Projections of the Felton Diversion inflows were determined using a correlation equation developed with the minimum mean daily flow at the San Lorenzo River at Big Trees gage during March of the current year. In many drought years, there will be no inflow from Felton Diversion due to inadequate streamflow.

Step 5: Determine Production from Other Sources

Water supply production from SCWD's other sources must be considered in order to determine the amount needed from Loch Lomond Reservoir to balance supply and demand, if possible. Projections of water production that may be anticipated from sources other than the reservoir can be estimated from the preceding season's rainfall. These projections are based on mathematical correlations to recent rainfall at the Newell Creek Watershed gage as shown in lines 1 through 3 of Table 8-2. As for the allocation of reservoir supplies, these correlations are also dependent on the hydrologic conditions of the preceding year. Again, the indicator used in the correlation equations is the streamflow at San Lorenzo River at Big Trees for August 31 of the preceding year.

Careful review of the historical records indicated that the total April to October stream diversions (North Coast and SLR) for a second consecutive dry year are less than diversions for the first dry year <u>even if the rainfall quantities and March 31 SLR flow included above are identical for the two given years</u>. In other words, the flows in the North Coast streams and SLR seem to diminish more rapidly during a second consecutive dry year even if recent rainfall and streamflows appear similar. This phenomenon is likely due to a decline in subsurface inflow to the streams and high infiltration of rainfall during a second consecutive dry year.

Step 6: Calculate Loch Lomond Production

The quantity of water which should actually be withdrawn from Loch Lomond in the April 1 to October 31 period is equal to the <u>lesser</u> of:

(1) the unmet demand after subtracting the production from other sources (line 13) from the total SCWD demand (line 7) for the April 1 through October 31 period; or

(2) the maximum amount of production allowed under the Loch Lomond operating rule which is equal to the allocation for use at Loch Lomond (line 10) less the natural demand (line 11) plus the inflow from Felton Diversion (line 12).

Step 7: Determine Required Conservation

If the projected production from other sources is not great enough to reduce the required production from Loch Lomond Reservoir below the allocation prescribed by the operating rule, the total demand in the April 1 through October 31 period cannot be met if the Loch Lomond operating rule (i.e., amount to be withdrawn) is stringently followed. The resulting unmet demands are listed on line 16 of Table 8-2. The average conservation required for the subsequent April 1 through October 31 period to balance available supplies and demand is then computed as the percentage of unmet demands (line 16) to the total SCWD demand (line 7).

Once the total shortfall or average required conservation percentage is determined, a plan for achieving the required demand reduction must be selected and enacted. The guidelines discussed below were used to carry out the operations analyses and as general evaluation criteria for the purposes of this study. In general, these guidelines are consistent with the SCWD's existing "Drought Contingency Plan," but not as detailed. When the proposed system for determining water supply deficiencies and related conservation level is adopted and a drought year is encountered, the SCWD may implement any appropriate actions or drought ordinance to accomplish the required conservation level. Therefore, the planning guidelines set forth below are not intended to replace or modify the SCWD's existing program.

The level of conservation that would be required within the SCWD service area was determined as follows:

> If the average conservation needed to balance available supplies and demand for April 1 through October 31 is less than 1 percent, conservation measures should not be implemented.
>
> If the average conservation needed to balance available supplies and demand for April 1 through October 31 is between 1 and 10 percent, a public information and education program should be implemented. Such a program may include advertisements, brochures, bill inserts, and community work. For this study, such a program was assumed to provide a 5 percent reduction in demand for the April 1 through October 31 period.
>
> If the average conservation needed to balance available supplies and demand for April 1 through October 31 is between 10 and 20 percent, a vigorous public information and education program should be conducted and the supplies and demands should be closely monitored to determine if mandatory rationing is required. For calculation purposes, a 5 percent reduction in demand was used for April (assuming only a public information program can be initiated), a 10 percent reduction in demand was used for May (continuing and expanding the public information program), and a constant percent reduction was used for June through October to provide the remaining required demand reduction. This percentage reduction could be obtained through voluntary efforts or

mandatory rationing. However, for the second consecutive drought year (as determined by the streamflow at San Lorenzo River at Big Trees for the preceding August 31), the demand reduction was increased to 10 percent for April (assumes public reaction would be prompt due to prior dry year) and a constant percent reduction was used for May through October.

If the average conservation needed to balance available supplies and demand for April 1 through October 31 is greater than 20 percent, it was assumed for this study that a vigorous public information program would be conducted immediately and preparation would be made for mandatory rationing beginning on June 1 or sooner. In the calculations, the distribution of the percentages for demand reductions is the same as that described above, but the subsequent percentage reductions were greater, likely requiring mandatory rationing.

It should be noted that any residual demand reductions remaining after lifting water use restrictions do not impact the results of the analysis because available supplies from stream diversions in November are normally adequate to meet normal demands. Also, any reductions in winter water use during a two-year drought do not affect the results of the operations studies because the normal demands are not high enough to require use of the water stored at Loch Lomond.

8.4 RESULTS OF OPERATIONS STUDIES

The firm yield and operational yield analyses described previously were performed on each of the water supply alternatives, with the exception of Alternatives 4, 8B, and 9. As reported in Chapter 7, Alternative 4 (Parallel Pipeline from SLR to GHWTP) has no discernible impact on the system yield, Alternative 8B (Soquel Creek Intertie) does not appear feasible, and Alternative 9 (Parallel Coast Pipeline) performs essentially the identical function as Alternative 3 (North Coast Pump Stations). Therefore, operations studies for these three alternatives were considered unnecessary.

As explained in Section 8.3, the Operations Model used in this study simulated the performance of the SCWD water system with the various water supply alternatives over the 1921-1986 hydrologic period. The assumed system upgrades included in Alternative 1 are included in the Operations Model and, therefore, all other alternatives inherently include the upgrades from Alternative 1.

Firm Yield Studies - The results of the firm yield analyses are summarized in Table 8-3. The firm yield computed for Alternative 1 (Upgrade Existing System) is 4240 MG/YR, which happens to be approximately equal to the current average annual demand in the SCWD service area. The additional increases in firm yield for the individual alternatives involving existing supplies varies from 5 to 530 MG/YR. Alternatives 11 and 12, involving new reservoirs, could provide a firm yield at or above the projected annual demand in year 2005 under the high growth scenario.

The impact of the potential new reservoirs was estimated by increasing the "available diversions" from the North Coast (for Alternative 11) or SLR-Tait Street (for Alternative 12) up to the hydraulic or water right limits for the entire duration of the 1976-77 drought. Coordinated reservoir operations were not integrated into the Operations Model. Therefore, the firm yield values for these two alternatives are probably conservative if adequate storage volume is provided at the new reservoir.

With the exception of Alternatives 11 and 12, the firm yield available from individually implementing each of the other alternatives is considerably less than the projected high growth demand of 5175 MG/YR. However, if several of the individual alternatives are implemented, the firm yield may approach or exceed the projected demand.

Operational Yield Studies - Table 8-4 summarizes the results of the operational yield analyses in terms of "supply deficiencies" and "required percentage reductions". Supply deficiencies occur when the given collection of water supply sources and facilities cannot meet the projected demand under the year 2005 high growth scenario during drought years. The required conservation percentages reflect the demand reduction needed to balance available supplies and demand during the peak use period of April to October. The "maximum month" percentage reductions represent the magnitude of conservation (e.g., voluntary reductions or mandatory rationing) which would be required during the peak summer months. Therefore, the effectiveness of water supply alternatives is indicated by the frequency and magnitude of "supply deficiencies" and the associated "required conservation percentages" occurring within the 66-year historical hydrologic period used in this study.

The proposed operating rule for allocating Loch Lomond Reservoir storage during droughts (see Section 8.3.4) has a major impact on the results displayed in Table 8-4. If more water is drawn out of Loch Lomond during the first year of a drought, the frequency of supply deficiencies would decrease but the magnitude of the required conservation in a second consecutive drought year would increase.

As shown in Table 8-4, some form of conservation would be required to meet year 2005 demand in approximately 7 of the 66 years under Alternative 1. However, most of these occurrences would only require minor demand reductions, attainable through voluntary conservation efforts. In conditions

Table 8-3

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SUMMARY OF FIRM YIELD ANALYSES

SUPPLY ALTERNATIVE	FIRM YIELD (MG/YR)	INCREMENTAL FIRM YIELD (MG/YR)
1. Upgrade Existing System	4,240	0
2A. Increase FD to 14 CFS	4,275	35
2B. Reduce FD Op. Margin	4,255	15
3. Add Pumps at North Coast	4,245	5
5A+5B. Additional Wells	4,555	315
6. Wastewater Reclamation	4,325	85
7A. Raise Newell Creek Dam 4'	4,400	160
7B. Raise Newell Creek Dam 14'	4,770	530
8A. Construct Intertie to SVWD	4,750	510
11. North Coast Reservoir	5,170	930
12. San Lorenzo R. Reservoir	5,355	1,115
Combination 1+2B+5A+5B	4,570	330
Combination 1+2B+5A+5B+8A	5,075	835

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Table 8-4

City of Santa Cruz Water Department
Water Master Plan

SUMMARY OF SUPPLY DEFICIENCIES

SUPPLY ALTERNATIVE	Calendar Year	SUPPLY DEFICIENCIES Annual (MG)	SUPPLY DEFICIENCIES Maximum Month (MG/MONTH)	REQUIRED PERCENT REDUCTIONS Annual	REQUIRED PERCENT REDUCTIONS Maximum Month 1/
1. Upgrade Existing System	1931	176	31	3%	5%
	1933	176	30	3%	5%
	1939	177	31	3%	5%
	1961	184	31	4%	5%
	1972	181	31	3%	5%
	1976	692	143	13%	24%
	1977	1,341	255	26%	41%
2A. Increase FD to 14 CFS	1939	177	31	3%	5%
	1961	184	31	4%	5%
	1972	181	31	3%	5%
	1976	692	143	13%	24%
	1977	1,279	243	25%	39%
2B. Reduce FD Op. Margin	1931	176	31	3%	5%
	1933	176	30	3%	5%
	1939	177	31	3%	5%
	1961	184	31	4%	5%
	1972	181	31	3%	5%
	1976	667	137	13%	23%
	1977	1,311	249	25%	40%
3. Add Pumps at North Coast	1931	153	31	3%	5%
	1933	176	30	3%	5%
	1939	177	31	3%	5%
	1961	184	31	4%	5%
	1972	181	31	3%	5%
	1976	667	137	13%	23%
	1977	1,311	249	25%	40%
5A+5B. Additional Wells	1976	435	83	8%	14%
	1977	1,057	199	20%	32%
6. Wastewater Reclamation	1931	176	31	3%	5%
	1933	176	30	3%	5%
	1961	184	31	4%	5%
	1972	181	31	3%	5%
	1976	615	125	12%	21%
	1977	1,247	237	24%	38%
7A. Raise Newell Creek Dam 4'	1931	176	31	3%	5%
	1972	181	31	3%	5%
	1976	563	113	11%	19%
	1977	1,247	237	24%	38%
7B. Raise Newell Creek Dam 14'	1976	176	30	3%	5%
	1977	1,057	199	20%	32%
8A. Construct Intertie with Scotts Valley WD	1976	176	30	3%	5%
	1977	898	168	17%	27%
11. North Coast Reservoir	1977	183	31	4%	5%
12. San Lorenzo R. Reservioir	---	0	0	0%	0%
Combination 1+2B+5A+5B	1976	408	77	8%	13%
	1977	1,026	193	20%	31%
Combination 1+2B+5A+5B+8A	1977	1,006	187	28%	30%

1/ Represents magnitude of required conservation program in summer months; values less than 10 percent would only require a public information program while values greater than 20 percent would likely require a mandatory rationing program; values between 10 and 20 percent would require a substantial voluntary conservation program or a moderate level of mandatory rationing.

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identical to those which occurred in 1976-77, major reductions of up to 24 to 41 percent would be necessary. Both the frequency and magnitude of the supply deficiencies and associated required percentage reductions decrease as facilities proposed under the various alternatives are added. As indicated by the values in Table 8-4, the 1976-77 period was the by far the most severe drought experienced in the Santa Cruz area between 1921 and 1986. Under these historical conditions, a major reduction in demand would be needed in 1977 under all individual alternatives except those involving new reservoirs. To illustrate the results of the simulated operations, the water supply production by source during the 1976-77 drought period is shown in Tables 8-5, 8-6, and 8-7 for Alternatives 1, 11, and 12, respectively.

8.5 ENVIRONMENTAL IMPACTS

In addition to the effect on the supply system's performance under drought conditions, potential environmental impacts also play an important role in determining the overall feasibility of water supply alternatives. The significant environmental impacts that will most likely result with implementation of each alternative are described in the following sections.

For the reasons described below, discussion of water quality impacts is limited. Outside of the new storage reservoirs, the various water supply alternatives do not present any dramatic change in the balance of supply production. Implementation of the proposed operating rules will result in descreased use of Loch Lomond in the winter months but will only have a minor or negligible impact on overall raw water quality at the Graham Hill Water Treatment Plant. Furthermore, all existing sources provide good quality and meet all drinking water standards. As for the proposed storage reservoirs, water from these sources will be similar in quality to SCWD's existing sources and will rarely be needed.

8.5.1 Alternative 1 - Upgrade Existing Production System

In general, implementation of the proposed upgrades to the existing production system will only result in minor environmental impacts because the various upgrades are related to maximizing or optimizing use of existing facilities and sources that are currently developed. Under this alternative, diversions from all sources will be increased to meet the growing demand. However, all facilities will be operated under existing regulatory constraints. Diversions from the North Coast will only increase slightly in the winter and spring months. Therefore, any adverse impacts on the fisheries on these streams and on riparian vegetation are expected to be minimal. An in-depth analysis of these potential impacts has not been conducted in this study.

Table 8-5

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WATER SUPPLY PRODUCTION FOR ALTERNATIVE 1
HIGH GROWTH DEMAND
(Values in million gallons)

Year/Month		North Coast	San Lorenzo River at Tait	Beltz Wells	Newell Creek Reservoir	San Lorenzo River Reservoir	Total Supply	Conservation Reduction
1974	OCT	101	220	56	84	0	461	0%
	NOV	92	226	22	0	0	340	0%
	DEC	108	128	56	19	0	311	0%
1975	JAN	110	206	0	0	0	316	0%
	FEB	143	98	44	0	0	285	0%
	MAR	175	86	0	65	0	326	0%
	APR	167	205	0	10	0	382	0%
	MAY	173	214	0	129	0	516	0%
	JUN	155	211	54	142	0	562	0%
	JUL	122	229	56	186	0	593	0%
	AUG	105	233	56	220	0	614	0%
	SEP	94	228	54	214	0	590	0%
	OCT	95	194	56	100	0	445	0%
	NOV	79	231	38	0	0	348	0%
	DEC	76	235	0	0	0	311	0%
1976	JAN	72	239	5	0	0	316	0%
	FEB	72	213	0	0	0	285	0%
	MAR	87	237	18	0	0	342	0%
	APR	79	231	54	19	0	383	5%
	MAY	67	237	56	127	0	487	10%
	JUN	57	194	54	111	0	416	24%
	JUL	57	155	56	184	0	452	24%
	AUG	53	176	56	116	0	401	24%
	SEP	49	158	54	69	0	330	24%
	OCT	57	192	56	54	0	359	24%
	NOV	51	201	54	38	0	344	0%
	DEC	57	208	46	0	0	311	0%
1977	JAN	63	237	16	0	0	316	0%
	FEB	57	213	15	0	0	285	0%
	MAR	68	235	39	0	0	342	0%
	APR	55	203	54	67	0	379	10%
	MAY	61	200	15	0	0	276	41%
	JUN	55	158	54	64	0	331	41%
	JUL	46	110	56	140	0	352	41%
	AUG	44	108	56	160	0	368	41%
	SEP	45	125	54	46	0	270	41%
	OCT	59	141	56	21	0	277	41%
	NOV	67	171	54	44	0	336	0%
	DEC	106	205	0	0	0	311	0%
1978	JAN	150	95	56	15	0	316	0%
	FEB	158	78	0	49	0	285	0%
	MAR	160	100	0	66	0	326	0%
	APR	167	153	0	43	0	363	0%
	MAY	173	212	0	131	0	516	0%
	JUN	159	211	54	134	0	558	0%
	JUL	158	220	56	162	0	596	0%
	AUG	120	229	56	218	0	623	0%
	SEP	105	226	54	123	0	508	0%
	OCT	82	237	56	97	0	472	0%

FILE: TBL-ALT.WK1/F796-03-JMK-41

Table 8-6

City of Santa Cruz Water Department
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WATER SUPPLY PRODUCTION FOR ALTERNATIVE 11
HIGH GROWTH DEMAND
(Values in million gallons)

Year/Month		North Coast	San Lorenzo River at Tait	Beltz Wells	Newell Creek Reservoir	San Lorenzo River Reservoir	Total Supply	Conservation Reduction
1974	OCT	101	220	56	84	0	461	0%
	NOV	92	226	22	0	0	340	0%
	DEC	108	128	56	19	0	311	0%
1975	JAN	110	206	0	0	0	316	0%
	FEB	143	98	44	0	0	285	0%
	MAR	175	86	0	65	0	326	0%
	APR	167	205	0	10	0	382	0%
	MAY	173	214	0	129	0	516	0%
	JUN	155	211	54	142	0	562	0%
	JUL	122	229	56	186	0	593	0%
	AUG	105	233	56	220	0	614	0%
	SEP	94	228	54	214	0	590	0%
	OCT	95	194	56	100	0	445	0%
	NOV	79	231	38	0	0	348	0%
	DEC	76	235	0	0	0	311	0%
1976	JAN	72	239	5	0	0	316	0%
	FEB	72	213	0	0	0	285	0%
	MAR	87	237	18	0	0	342	0%
	APR	178	225	0	0	0	403	0%
	MAY	184	237	56	64	0	541	0%
	JUN	178	194	54	122	0	548	0%
	JUL	184	155	56	200	0	595	0%
	AUG	184	176	56	111	0	527	0%
	SEP	178	158	54	44	0	434	0%
	OCT	184	192	56	40	0	472	0%
	NOV	178	166	0	0	0	344	0%
	DEC	57	208	46	0	0	311	0%
1977	JAN	63	237	16	0	0	316	0%
	FEB	57	213	15	0	0	285	0%
	MAR	68	235	39	0	0	342	0%
	APR	178	203	19	0	0	400	5%
	MAY	184	200	56	0	0	440	5%
	JUN	178	158	54	143	0	533	5%
	JUL	184	110	56	216	0	566	5%
	AUG	184	108	56	244	0	592	5%
	SEP	178	125	54	77	0	434	5%
	OCT	184	141	56	65	0	446	5%
	NOV	178	158	0	0	0	336	0%
	DEC	106	205	0	0	0	311	0%
1978	JAN	150	95	56	15	0	316	0%
	FEB	158	78	0	49	0	285	0%
	MAR	160	100	0	66	0	326	0%
	APR	167	153	0	43	0	363	0%
	MAY	173	212	0	131	0	516	0%
	JUN	159	211	54	134	0	558	0%
	JUL	158	220	56	162	0	596	0%
	AUG	120	229	56	218	0	623	0%
	SEP	105	226	54	123	0	508	0%
	OCT	82	237	56	97	0	472	0%

FILE: TBL-ALT.WK1/F796-03-JMK-41

Table 8-7

City of Santa Cruz Water Department
Water Master Plan

WATER SUPPLY PRODUCTION FOR ALTERNATIVE 12
HIGH GROWTH DEMAND
(Values in million gallons)

Year/Month		North Coast	San Lorenzo River at Tait	Beltz Wells	Newell Creek Reservoir	San Lorenzo River Reservoir	Total Supply	Conservation Reduction
1974	OCT	101	220	56	84	0	461	0%
	NOV	92	226	22	0	0	340	0%
	DEC	108	128	56	19	0	311	0%
1975	JAN	110	206	0	0	0	316	0%
	FEB	143	98	44	0	0	285	0%
	MAR	175	86	0	65	0	326	0%
	APR	167	205	0	10	0	382	0%
	MAY	173	214	0	129	0	516	0%
	JUN	155	211	54	142	0	562	0%
	JUL	122	229	56	186	0	593	0%
	AUG	105	233	56	220	0	614	0%
	SEP	94	228	54	214	0	590	0%
	OCT	95	194	56	100	0	445	0%
	NOV	79	231	38	0	0	348	0%
	DEC	76	235	0	0	0	311	0%
1976	JAN	72	239	5	0	0	316	0%
	FEB	72	213	0	0	0	285	0%
	MAR	87	237	18	0	0	342	0%
	APR	79	231	54	39	0	403	0%
	MAY	67	237	56	181	0	541	0%
	JUN	57	194	54	0	243	548	0%
	JUL	57	155	56	0	327	595	0%
	AUG	53	176	56	94	148	527	0%
	SEP	49	158	54	173	0	434	0%
	OCT	57	192	56	167	0	472	0%
	NOV	51	201	54	38	0	344	0%
	DEC	57	208	46	0	0	311	0%
1977	JAN	63	237	16	0	0	316	0%
	FEB	57	213	15	0	0	285	0%
	MAR	68	235	39	0	0	342	0%
	APR	55	203	54	109	0	421	0%
	MAY	61	200	56	150	0	467	0%
	JUN	55	158	54	0	294	561	0%
	JUL	46	110	56	43	341	596	0%
	AUG	44	108	56	43	372	623	0%
	SEP	45	125	54	0	233	457	0%
	OCT	59	141	56	213	0	469	0%
	NOV	67	171	54	44	0	336	0%
	DEC	106	205	0	0	0	311	0%
1978	JAN	150	95	56	15	0	316	0%
	FEB	158	78	0	49	0	285	0%
	MAR	160	100	0	66	0	326	0%
	APR	167	153	0	43	0	363	0%
	MAY	173	212	0	131	0	516	0%
	JUN	159	211	54	134	0	558	0%
	JUL	158	220	56	162	0	596	0%
	AUG	120	229	56	218	0	623	0%
	SEP	105	226	54	123	0	508	0%
	OCT	82	237	56	97	0	472	0%

FILE: TBL-ALT.WK1/F796-03-JMK-41

8.5.2 Alternative 2A - Increase Capacity of Felton Diversion

By increasing the capacity of the pump station at Felton Diversion, flows in the San Lorenzo River downstream of the point of diversion would occasionally be reduced relative to historical flows. However, the required fish releases would not be impacted and the increased diversions would not exceed the diversion rates specified in the existing SCWD water rights for Felton Diversion. The increased diversions may result in slightly higher water levels at Loch Lomond Reservoir than otherwise would occur in the future. These slightly higher water levels would presumably be beneficial to both fishery habitat and recreation at the reservoir. No other discernible impacts are anticipated.

8.5.3 Alternative 2B - Reduce Operating Margin at Felton Diversion

Environmental impacts due to reducing the operating margin at Felton Diversion are similar to those for Alternative 2A. Flows downstream of the point of diversion would be slightly lower in dry years than those that have historically occurred or would otherwise occur in the future.

8.5.4 Alternative 3 - North Coast Pump Stations

Under this alternative, diversions from the North Coast sources would be increased in the winter and spring months over current levels. The pump stations would not significantly increase diversions during the summer and fall months since the available runoff is typically less than the current diversion capacities. The increased diversions during the winter and spring months may have negative impacts on the fisheries on these streams and on riparian vegetation and phreatophytes in the area. These environmental impacts would be most pronounced at Majors Creek since this source has been underutilized in the past due to the prevailing hydraulic conditions. Because water from the North Coast sources is of better quality than other SCWD supplies, increased use of these sources would improve the overall water quality of water delivered to SCWD's water users.

8.5.5 Alternative 4 - Parallel Pipeline from SLR to GHWTP

Because no significant increases in water production are expected from construction of a parallel pipeline from SLR to GHWTP, no adverse environmental impacts would occur from its implementation besides minor disturbances during construction. This alternative would provide improved operations and, consequently, would improve the quality and reliability of water service in the SCWD system.

8.5.6 Alternatives 5A & 5B - Additional Groundwater Wells

Additional use of groundwater by the SCWD may cause localized or general declines in the groundwater levels. Groundwater extractions from the Harvey West wells may also reduce the streamflow at the San Lorenzo River if a

hydraulic connection exists. However, use of additional groundwater by SCWD would not be expected to have major impacts, primarily because of the limited amount of groundwater proposed for withdrawal. During drought years when groundwater production will be maximized, adverse impacts on the groundwater basin would be possible. Any local domestic or agricultural wells could run dry if groundwater levels drop significantly.

Water quality at the Thurber Lane wells is expected to be similar in quality to that from the Beltz wells and would probably require treatment for iron and manganese removal. Because the groundwater would be treated to meet water quality standards and the amount of groundwater represents a small percentage of the total SCWD supply, the overall water quality in the SCWD would not be significantly affected by increased use of groundwater.

8.5.7 Alternative 6 - Wastewater Reclamation

Use of reclaimed wastewater from Scotts Valley for turf irrigation would reduce flows at the Santa Cruz ocean outfall. Potential health concerns associated with using the reclaimed wastewater in public areas such as the Pasatiempo Golf Course would be mitigated by advanced treatment and disinfection of the wastewater, frequent water quality testing, and isolation of the reclaimed wastewater system from the potable water system. No other discernible impacts are anticipated.

8.5.8 Alternatives 7A & 7B - Enlarge Loch Lomond Reservoir

Enlargement of Loch Lomond Reservoir by raising Newell Creek Dam would allow SCWD to capture some of the Newell Creek streamflow currently lost to spill. However, the SCWD water right to store water at this site would require modification to allow for increased storage. The application for this modification would likely be strongly protested since local environmentalists are known to be displeased with the current release requirement originally negotiated with the State Department of Fish and Game (State DFG) and, furthermore, would likely oppose any additional water diversions. However, an increase in downstream releases to mitigate environmental concerns may be more than offset by the addition of valuable storage. Therefore, this alternative could actually improve fisheries habitat in Newell Creek while providing additional water supplies to the SCWD. A detailed study of reservoir operations and fisheries in Newell Creek would be necessary to verify this possibility.

The major impact of this alternative would be slight reductions in flows in Newell Creek and the SLR, primarily during major storms when the reservoir might otherwise be spilling. Due to slight decreases in flows, potential downstream impacts may be considered significant, but would not be major. Enlargement of the reservoir would also result in higher water levels at the reservoir. The existing concession stand and deck would probably have to be relocated, but this modification would not be difficult or disruptive. Slight modifications to the access roads and ramps would also be required.

Up to 50 acres of land would be inundated by the increase in water level. Possible loss of wildlife habitat or cultural resources around the reservoir surface may result from this newly inundated area.

Because the negative impacts associated with enlargement of Loch Lomond Reservoir are relatively minor, the impacts for this alternative are far less severe than for construction of a new dam and reservoir.

8.5.9 Alternative 8A - Scotts Valley Intertie

The proposed intertie with the Scotts Valley Water District (SVWD) would have some major environmental impacts which would have to be closely studied prior to a final determination on the feasiblity of this alternative. Of primary importance is the impact on the Scotts Valley groundwater basin. During non-drought periods, the impact on the basin should be positive. Delivery of treated water from SCWD into the SVWD system would result in higher groundwater levels, improved water quality for many SVWD customers, and reduced operating costs for SVWD. However, during drought years when SCWD would request substantial withdrawals from the groundwater basin, the groundwater basin and surface flows in Bean Creek may be adversely impacted. Detailed groundwater modelling would likely be necessary to evaluate the projected impact of the proposed intertie program and to provide guidance on how the program should be implemented. Possible adverse impacts are related to temporarily lowered groundwater elevations which, in turn, may cause permanent damage to the basin, dry up some shallow wells, and reduce flows in Bean Creek (flows are already overprescribed during dry periods).

The possibility of growth-inducement in both Santa Cruz and Scotts Valley could be mitigated by the terms of the intertie agreement, which would clearly indicate the purpose of the program as providing emergency supplies through a conjunctive use, "banking" scheme.

Deliveries to SVWD in the winter months would require additional diversions from SCWD's current sources, primarily the SLR-Tait Street diversion and Loch Lomond Reservoir. These two surface water sources have excess water available in most or all years during the winter months. As for prior alternatives, increased diversions would result in slightly lower streamflows downstream of the SCWD points of diversions and, consequently, could impact fishery habitats and riparian vegetation.

8.5.10 Alternative 9 - Direct Diversion on Zayante Creek

A new direct diversion facility on Zayante Creek would have several major environmental impacts. Fishery and wildlife downstream of the point of diversion may be adversely affected due to the reduced flow volume, reduction in flushing flows, and other factors. Vegetation may also be impacted due to changes in stream levels and frequency of inundation. Stringent requirements for in-stream releases such as those proposed in the COUNTY MP

would be requested by State DFG and local environmentalists to reduce or eliminate these potential adverse impacts.

Also, diversions from Zayante Creek would reduce flows at the SCWD's diversions on the SLR.

8.5.11 Alternative 10 - Parallel Coast Pipeline

Similar to Alternative 3, paralleling of the upper reaches of the Coast Pipeline would increase diversions from the North Coast supplies in the winter and spring. These increased diversions may have negative impacts on the fisheries on these streams and on riparian vegetation in the area.

8.5.12 Alternative 11 - North Coast Reservoir

There are obviously major adverse environmental impacts associated with construction of a new dam and reservoir on a large stream. Some of the most significant are:

(1) The dam would act as a barrier to fish migration and reduce potentially valuable fisheries habitat upstream;

(2) Downstream flows would be reduced, which could impair downstream fisheries habitat and riparian vegetation;

(3) Flushing flows would be considerably reduced and/or altered;

(4) A considerable amount of currently undisturbed wildlife habitat or existing roads and structures would be inundated by the reservoir.

(5) Although in this instance the reservoir would primarily be used to provide protection against droughts, the creation of new water supplies may induce additional growth in the SCWD service area.

The SCWD's experiences with the proposed Zayante Creek Dam Project exemplify the considerable difficulties associated with constructing new dams due to environmental and other concerns. The State DFG, local fishermen, and local environmentalists are strongly opposed to any new dams on major streams due to the continuing decline in the amount of adequate fisheries habitat. Even if all environmental concerns are adequately addressed and a dam is approved, the required in-stream releases from the reservoir can constitute a major portion of the average natural inflow. In the COUNTY MP, it was concluded that construction of new reservoirs on major streams in Santa Cruz County is no longer feasible under the anticipated suggested release requirements.

Because a new reservoir for the SCWD would only be needed during an extended dry period, operation of the new reservoir could be adjusted to minimize

impacts on downstream fishery and wildlife habitats. The new reservoir could be filled after construction and remain relatively full until large withdrawals are needed in a severe drought. Therefore, during non-drought periods, natural inflows to the reservoir could be "bypassed" through the reservoir as outflows except to make up for losses due to evaporation and seepage. The available storage could possibly enhance the flow conditions downstream of the dam by regulating the natural flows to best suit the needs of the local habitat. The presence of coastal wetlands and lagoons would pose additional complications for a proposed North Coast Reservoir.

If a North Coast Reservoir is constructed, regular use of the reservoir would be desirable from an operational viewpoint. By coordinating the operations of a new North Coast Reservoir with Loch Lomond Reservoir and other sources on an ongoing basis, all aspects (e.g., yield, cost, quality) of the SCWD supply system could be improved. However, "regular" use, as opposed to leaving the reservoir solely for drought protection, would require additional diversions from the SCWD's existing North Coast sources. This type of operation would present additional adverse impacts by reducing flows on other streams.

Although the two streams (Laguna and Baldwin Creeks) considered in this study for a North Coast Reservoir are not "major" streams in relation to other streams in Santa Cruz County, each is known to support fisheries habitat. If the City Council elects to pursue implementation of a North Coast Reservoir, a considerable amount of environmental studies would be needed to determine the precise impacts and to develop related mitigation measures. The potential impacts of mitigation measures on the feasibility and cost of a proposed reservoir project have not been evaluated in this study. For this reason, the proposed plans, project yields, and related cost estimates presented in this study can only be considered to be preliminary evaluations. Complete feasibility studies should be conducted prior to or in conjunction with the environmental work.

8.5.13 Alternative 12 - Upper San Lorenzo River Reservoir

Construction of a new dam and reservoir in the upper reaches of the San Lorenzo River watershed has essentially the same impacts as those listed previously for a North Coast Reservoir. A reservoir in the upper reaches of the San Lorenzo River would be filled after construction and will remain so until needed in droughts. This project would also have the potential for possibly enhancing reaches of the San Lorenzo River during drought years by releasing flow for eventual recapture at the SLR-Tait Street diversion.

As explained for Alternative 11, the impacts on fisheries and other biological resources is of utmost concern to the State DFG and other local interests. In fact, State DFG recently improved habitat in the vicinity of the Waterman Gap damsite. Therefore, strong opposition to this project can also be expected.

If the City Council elects to pursue implementation of an Upper San Lorenzo River Reservoir, a considerable amount of environmental studies would be needed to determine the precise impacts and to develop related mitigation measures. The potential impacts of mitigation measures on the feasibility and cost of a proposed reservoir project have not been evaluated in this study.

8.6 COST ESTIMATES

Preliminary cost estimates were developed for each water supply alternative to aid in the evaluation process. The estimated cost of an alternative relative to its impact on firm yield or the extent of water supply deficiencies gives a true indication of the alternative's overall effectiveness.

Breakdowns of quantities and unit costs are included in Appendix F of this report. The unit costs were obtained from manufacturers, experience on similar projects, standard cost estimating manuals, the COUNTY MP, and SCWD records. All of the costs are given in 1988 dollars. Annual O&M costs were escalated at 4 percent over 30 years then discounted to a present worth at 8 percent to account for the value of money and inflation.

A summary of the costs for each viable alternative is given in Table 8-8. No cost estimates have been prepared for Alternatives 8B and 9 since these alternatives were considered infeasible as explained elsewhere in this report. Table 8-8 lists the capital construction costs, the first year O&M costs, the first year energy & treatment costs, and the total equivalent annual costs for the alternative. Both the O&M and energy & treatment costs include only the incremental costs relative to Alternative 1 (the "base case"). Negative values shown for the additional energy and treatment costs indicate that cost savings are incurred under the given alternative by using lower cost sources to a greater extent.

The total equivalent annual costs were determined by summing the present worth of all future costs over 30 years then translating the total present worth cost into an equivalent annual cost. An equivalent annual cost is needed to compute the unit cost of water supplies relative to yield. The total equivalent annual costs were determined using a real interest rate of 4 percent over 20 years to account for inflation and prevailing financing terms. It should be noted that the equivalent annual costs shown for Alternatives 2A through 12 do not include the costs of upgrading the existing system as given in Alternative 1; the true equivalent annual costs for these alternatives also includes $27,000/YR for implementation of Alternative 1 since the facilities for Alternative 1 are inherently included in all other alternatives.

Table 8-8

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SUMMARY OF ESTIMATED COSTS FOR WATER SUPPLY ALTERNATIVES

Alternative	Construction	Additional O & M /1	Additional Energy and Treatment 1/	Equivalent Annual Costs /2
1	$115,000	$15,000	$0	$27,000
2A	$1,879,000	$19,000	$10,000	$174,000
2B	$54,000	$3,000	$0	$8,000
3	$304,000	$4,000	($5,000)	$21,000
4	$490,000	$5,000	($9,000)	$31,000
5A+5B	$653,000	$21,000	$3,000	$77,000
6	$615,000	$16,000 3/	($12,000)4/	$50,000
7A	$423,000	$0	$1,000	$32,000
7B	$2,000,000	$0	$10,000	$160,000
8A	$1,825,000	$40,000	$17,000	$205,000
10	$1,167,000	$12,000	($29,000)	$65,000
11	$15,000,000	$100,000	$6,000	$1,236,000
12	$10,000,000	$100,000	$3,000	$864,000

1/ First year costs, inflation not included.
2/ 4% real interest rate (difference between value of money and inflation) over 20 year period.
3/ Based on continued operations at Scotts Valley; if wastewater operations are consolidated at Santa Cruz WTP, cost would increase to $60,000.
4/ Costs for producing approximately 70 MG/YR of reclaimed wastewater is included under Additional O&M.

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8.7 EVALUATION OF ALTERNATIVES

8.7.1 Introduction

The results of the operations studies for each alternative studied, along with the equivalent annual costs, are presented in Table 8-9. Because no operations studies were conducted for Alternatives 4, 9, and 10, these alternatives are not listed in the table. However, qualitative evaluations of these three alternatives are presented in following subsections. As previously explained, the theoretical firm yields shown in Table 8-9 represent the level of demand which can be met every year without any supply deficiencies.

The results of the operational yield studies shown in Table 8-3 were used to develop the other information shown in Table 8-9. As previously indicated, these results are based on the year 2005 high growth demand scenario. If the low growth scenario were used, supply deficiencies would occur less frequently and be of smaller magnitude.

In the results for the operational yield analyses shown in Table 8-9, the "Full Supply" column indicates the percentage of time that the entire 5175 MG annual demand (year 2005, high growth scenario) can be met by the SCWD supply system for each alternative. The other columns indicate the percentage of time that voluntary conservation or mandatory rationing would likely be needed. Finally, the maximum annual supply deficiency under the most critical historical drought (1977) for each alternative is also presented.

A comparison of the results for each alternative relative to the results for Alternative 1 (the "base case") is given in Table 8-10. Relative to Alternative 1, increases in firm yield and decreases in maximum supply deficiencies were computed for each of the alternatives. Because firm yield is often used in this type of study but the supply deficiencies from operational yield studies are considered better measures of water supply capability, two sets of "yields" have been used in this table.

The unit costs of increasing the firm yield and reducing the supply deficiencies were then computed by dividing the equivalent annual cost by the increase in firm yield or the reduction in supply deficiency. The resultant values represent the approximate unit cost of developing additional water supplies to increase the dry year yield of the SCWD supply system.

The following sections contain complete evaluations for each water supply alternative considered in this study, with the exception of Alternative 8B (Soquel Creek Intertie) which is considered infeasible for reasons explained in Section 7.12.

Table 8-9

City of Santa Cruz Water Department
Water Master Plan

SUMMARY OF ALTERNATIVES

SUPPLY ALTERNATIVE	FIRM YIELD (MG/YR)	OPERATIONAL YIELD ANALYSES — PERCENTAGE OF YEARS WITH: Full Supply	Voluntary 1/ Conservation	Mandatory 2/ Rationing	MAXIMUM ANNUAL DEFICIENCY (MG/YR)	EQUIVALENT ANNUAL COST 3/ ($)
1. Upgrade Existing System	4,240	89%	8%	3%	1,341	$27,000
2A. Increase FD to 14 CFS	4,275	92%	5%	3%	1,279	$174,000
2B. Reduce FD Op. Margin	4,255	89%	8%	3%	1,311	$8,000
3. Add Pumps at North Coast	4,245	89%	8%	3%	1,311	$21,000
5A+5B. Additional Wells	4,555	97%	2%	2%	1,057	$77,000
6. Wastewater Reclamation	4,325	91%	6%	3%	1,247	$50,000
7A. Raise Newell Creek Dam 4'	4,400	94%	3%	3%	1,247	$32,000
7B. Raise Newell Creek Dam 14'	4,770	97%	2%	2%	1,057	$160,000
8A. Construct Intertie to SVWD	4,750	97%	2%	2%	898	$205,000
11. North Coast Reservoir	5,170	98%	2%	0%	183	$1,236,000
12. San Lorenzo R. Reservoir	5,355	100%	0%	0%	0	$864,000
Combination 1+2B+5A+5B	4,570	97%	2%	2%	1,026	$112,000
Combination 1+2B+5A+5B+8A	5,075	98%	0%	2%	1,006	$317,000

1/ Requires public information program for reductions of up to 15 percent of the summer monthly demand.
2/ Mandatory rationing may be needed for reductions of more than 15 percent of the summer monthly demand.
3/ Present worth of total construction costs, additional O&M costs, and energy and treatment costs for implementing each alternative independently; the costs for Alternative 1 should be added to the costs shown for each alternative to give the true cost of implementing the alternative.

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Table 8-10

City of Santa Cruz Water Department
Water Master Plan

COMPARISON OF ALTERNATIVES 1/

SUPPLY ALTERNATIVE	INCREMENTAL EQUIVALENT ANNUAL COST ($/YR)	FIRM YIELD ANALYSIS: INCREASED YIELD (MG/YR)	FIRM YIELD ANALYSIS: UNIT COST OF INCREASING YIELD ($/MG)	OPERATIONAL YIELD ANALYSIS: REDUCTION IN MAXIMUM DEFICIENCY (MG/YR)	OPERATIONAL YIELD ANALYSIS: UNIT COST OF REDUCING DEFICIENCIES ($/MG)
1. Upgrade Existing System	$0	0	$0	0	$0
2A. Increase FD to 14 CFS	$174,000	35	$4,971	62	$2,806
2B. Reduce FD Op. Margin	$8,000	15	$533	30	$267
3. Add Pumps at North Coast	$21,000	5	$4,200	30	$700
5A+5B. Additional Wells	$77,000	315	$244	284	$271
6. Wastewater Reclamation	$50,000	85	$588	94	$532
7A. Raise Newell Creek Dam 4'	$32,000	160	$200	94	$340
7B. Raise Newell Creek Dam 14'	$160,000	530	$302	284	$563
8A. Construct Intertie to SVWD	$205,000	510	$402	443	$463
11. North Coast Reservoir	$1,236,000	930	$1,329	1,158	$1,067
12. San Lorenzo R. Reservoir	$864,000	1,115	$775	1,341	$644
Combination 1+2B+5A+5B	$112,000	330	$339	315	$356
Combination 1+2B+5A+5B+8A	$317,000	835	$380	335	$946

1/ All comparisons are made relative to Alternative 1.

COMP.WK1/F796-04-RJM-2

8.7.2 Alternative 1 - Upgrade Existing Production System

As indicated in Table 8-9, with the implementation of the Alternative 1 upgrades, the entire demand of 5175 MG/YR could be met in almost 90 percent of all years while voluntary conservation would be needed in about 8 percent of all years. The indicated percentage for years requiring mandatory rationing represent the two years of the 1976-77 drought.

Because the existing SCWD supply system without the "upgrades" is considered by many to be unable or barely adequate to meet current demands, the results of the operations studies were unexpected and their validity appeared questionable. However, the results of the operation studies for the upgraded existing supply system appear reasonable after considering the following explanations, which are listed in order of importance:

(1) The proposed operating rules used in the Operations Model are generally geared toward maintaining Loch Lomond Reservoir as full as possible while still considering production cost and water quality. Under current operations, Loch Lomond is used more liberally in order to reduce costs, improve water quality, and for other operational reasons. Although the proposed operating rules will increase production costs by increasing the use of more costly sources, the preservation of storage at Loch Lomond is extremely critical to safeguarding the system's drought year yield. In essence, the proposed operating rules reserve Loch Lomond supplies to a much greater degree than current operations. Therefore, although production costs increase slightly, adequate supplies are available from Loch Lomond during most dry years to eliminate or minimize supply deficiencies.

(2) Based on discussions with SCWD staff, the Beltz well system is assumed to produce about 2 MGD for sustained periods during dry years in the operations studies. This level of supply, which is extremely valuable since it is available during the critical summer months, has not been available to the SCWD in the past. The Beltz well system can produce about 60 MG per month, or about 300 to 400 MG during the critical April to October period.

(3) As explained in Chapter 6, the Coast Pipeline will soon become a purely raw water transmission pipeline, without the stringent turbidity constraints (1 NTU) currently imposed due to the domestic services which are served directly off the pipeline. With the domestic services removed from the Coast Pipeline, runoff with turbidity up to 25 NTUs can be diverted in the future. Therefore, greater diversions from the North Coast can be made during rainy periods which, in turn, preserves Loch Lomond supplies (which are now used when the North Coast sources are shut down) for later use in dry periods.

An estimate of the increased production capacity for the North Coast sources was derived through comparison of monthly diversions for historical and simulated conditions (applying assumed diversion capacities to actual streamflow data) during Water Years (WY) 1970-76. The results of this analysis are presented in Table 8-11. As indicated, the increase in average monthly diversions for simulated conditions varies from 7 percent in September to 58 percent in December. The higher percentage increases during the winter months, when most rainfall occurs, reflect the impact of the higher turbidity limit. Even in the drier months, the higher turbidity limits probably yield about one to three days of additional diversions. In addition to the higher turbidity limit, there are other factors causing the indicated differences:

- Historically, North Coast diversions frequently were made to Bay Street Reservoir, which is no longer allowed. When adequate runoff (inflow) is available such that it is not the controlling factor, diversion through the Coast Pump Station to GHWTP (assumed in simulation) instead of to Bay Street Reservoir increases flows in the North Coast pipeline by adding approximately 0.5 MGD to the diversion capacity.

- Under historical operations, some water may have been "lost" when diversions (or pipeline) were shut down for repair, maintenance, or other reasons. Review of operations records indicate that certain diversions were taken out of service for extended periods when flow was available. The simulated conditions have accounted for such outages through "down time" but historical down times may have been greater during this particular seven-year period.

In addition to the proposed operating rules, increased use of Beltz wells, and increased diversions from the North Coast, Alternative 1 includes the addition of two large pumping units at Felton Booster Station. These units will not be needed until at least year 2000 and after that will only be needed on a very infrequent basis. However, in certain dry years when production from other sources is relatively low, the required production rate from Loch Lomond may exceed the current pumping capacity. <u>These additional pumping units may not be needed if other facilities or sources which would reduce the required flow from Loch Lomond are added</u>.

8.7.3 Alternative 2A - Increase Capacity of Felton Diversion

The results for increasing the capacity of Felton Diversion up to 14 CFS indicate only a slight increase in firm yield and small decrease in the frequency and magnitude of supply deficiencies. Because of fish releases (20 CFS in most months) and the need for an operating "cushion" or margin, flow in the SLR at Felton Diversion must exceed 30 CFS in order to utilize more than the current capacity of 9 CFS. During critical drought periods such as 1976-77, the total streamflow is generally less than 30 CFS. Therefore, the additional 5 CFS of capacity provided at Felton Diversion could

Table 8-11

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NORTH COAST PRODUCTION
FOR WY 1970-1976

MONTH	AVERAGE MONTHLY (MG/MONTH) Actual	Simulated	PERCENT INCREASE
October	85	100	18%
November	78	107	37%
December	85	134	58%
January	106	146	38%
February	110	140	27%
March	113	153	35%
April	128	149	16%
May	133	148	11%
June	117	131	12%
July	96	119	24%
August	90	104	16%
September	84	90	7%

WATER YEAR	AVERAGE ANNUAL (MG/YR) Actual	Simulated	PERCENT INCREASE
1970	1567	1779	14%
1971	1291	1647	28%
1972	907	1092	20%
1973	1441	1813	26%
1974	1404	1880	34%
1975	1180	1577	34%
1976	788	869	10%

FILE: COAST70S.WK1; DISK: F796-04-RJM-3

not be used effectively. In certain instances such as a prolonged, mild drought, this alternative may become more effective.

The slight improvement in system yield coupled with the high costs of implementing this alternative results in very high unit costs (over $2800/MG) for this alternative. However, the cost of this plan was based on installation of a parallel pipeline along the entire distance betwen Felton BS and Loch Lomond Reservoir. Further study will probably indicate that only limited portions of the existing pipeline would have to be paralleled or replaced. Therefore, the unit cost of this alternative may decrease considerably, perhaps as low as $1000/MG.

8.7.4 Alternative 2B - Reduce Operating Margin at Felton Diversion

Unlike the Felton Diversion improvements suggested in Alternative 2A, the reduction of the operating margin at Felton Diversion proved to be a cost-effective means of increasing the performance of the supply system. By reducing the operating margin at Felton Diversion, almost all available water (above the required fish release) during low flow periods could be diverted to Loch Lomond Reservoir. Thus, this improvement would be effective in increasing the system's performance in drought years. Although the increase in firm yield and decrease in deficiencies are extremely small, the low cost of implementing this alternative results in a unit cost of $267 to $533 per MG. However, the overall impact of this alternative on the supply system would be almost negligible.

8.7.5 Alternative 3 - North Coast Pump Stations

By adding two pump stations on the North Coast supply system, diversions of low-cost, high quality water from these sources could be increased. The average annual production of North Coast supplies would increase from about 1480 MG under Alternative 1 to about 1730 MG with the new pump stations. As indicated in Table 8-8, the annual total system cost for energy and treatment under this alternative would be reduced by about $5000 per year relative to Alternative 1 despite the fact overall water production will increase.

Although this alternative would increase the system's flexibility and would provide some annual cost savings, <u>the additional hydraulic capacity for North Coast diversions would not significantly improve the capability of the supply system in producing drought year yield</u>. The increased capacity could only be used when adequate runoff is available, typically during the winter and spring months. In such months, demand in the SCWD system is relatively low and can easily be met from the existing North Coast facilities and the SLR-Tait Street diversion. In wet years, the additional capacity could be utilized into the summer months when demand is higher. However, adequate supplies from SCWD's other sources would be available in such years. For these reasons, the increased use of North Coast water under this alternative

would be of little benefit with regard to the system's capability to meet demands in a drought year.

Because this alternative would have essentially no impact on the system yield, the resulting unit costs are extremely high, suggesting that this alternative would not be an effective means of producing additional water supplies.

8.7.6 Alternative 4 - Parallel Pipeline from SLR to GHWTP

Installation of a parallel pipeline between the Coast Pump Station and the GHWTP would have virtually no impact on the system's yield despite the added operational flexibility and redundancy it would provide. A slight increase in capacity would be realized but, as for the previous alternative, this additional capacity would not impact the system's capability to meet drought year demands.

Because both the North Coast and SLR-Tait Street sources of water are delivered through a common pipeline, the added reliability and other operational advantages offered by a parallel pipeline would be valuable. Because the operational improvements this alternative offers are difficult to quantify, the value of an additional pipeline is relatively subjective. Including the energy savings from reduced head losses, the annual cost of this alternative is about $31,000. The parallel pipeline would be recommended if one of the proposed reservoirs (Alternatives 11 and 12) were constructed.

8.7.7 Alternatives 5A & 5B - Additional Groundwater Wells

Construction of additional groundwater wells in the Santa Cruz area would provide additional water supply when it is needed most, in the high demand periods of summer and during drought periods when surface supplies are low. In effect, the wells would provide access to a large underground storage reservoir which could be tapped when other available sources cannot meet demands. As shown by the results of the operations studies, installation of these wells would be a cost-effective means of reducing supply deficiencies. The percentage of years in which the entire demand could be met increased from 89 percent under Alternative 1 to 97 percent for this alternative. Supply deficiencies would only occur during severe droughts such as 1976-77.

The significant reduction in supply deficiencies could be expected despite the relatively low capacity of the wells because of the availability of the supplies during critical periods. Due to its effectiveness, the unit cost for this alternative has been estimated to be $244 to $271 per MG.

8.7.8 Alternative 6 - Wastewater Reclamation

The results of the operations studies indicate that implementation of wastewater reclamation would be marginally cost-effective. The impacts on firm

yield and supply deficiencies would be relatively small because of the limited application for use of reclaimed wastewater. The unit cost of this alternative is estimated to be $532 to $588 per MG.

This alternative would be economically less desirable if the City of Scotts Valley decides to shut down the wastewater treatment plant as additional O&M costs would be incurred.

8.7.9 Alternatives 7A & 7B - Enlarge Loch Lomond Reservoir

Analyses for increasing the storage capacity at Loch Lomond Reservoir by raising Newell Creek Dam were performed for two enlargement sizes. As expected, by obtaining valuable additional storage, each alternative would result in significant increases in firm yield and decreases in supply deficiencies. The moderate enlargement created by raising the dam by only 4 feet proved to be more cost effective (only $200 to $340 per MG), but did not produce as great a reduction in the number and magnitude of supply deficiencies as the bigger enlargement.

Enlargement of Loch Lomond Reservoir would require modification of SCWD's water right to allow for increased storage. If the City Council elects to pursue one of these alternatives, the current water rights may be subject to revision and stricter fish releases may be required. If releases such as those suggested in the COUNTY MP are imposed, the additional yield produced by the increased storage would be reduced and SCWD may be left with <u>less</u> water available from Loch Lomond Reservoir. The analyses used in this study were based on the <u>current</u> fish release requirements; thus, the yields shown in the tables may be overstated.

The structural feasibility of enlarging the reservoir is not known at this time but would have to be investigated. The California Division of the Safety of Dams would require structural analyses of the dam and hydrologic and hydraulic studies of the spillway for any proposed enlargement.

8.7.10 Alternative 8A - Scotts Valley Intertie

As discussed in Chapter 7, an intertie program with SVWD presents a viable alternative for significantly increasing the SCWD's capability to endure severe droughts. Under this alternative, a conjunctive use program would be developed whereby excess surface water would be delivered to SVWD in the winter and spring for use in lieu of the current groundwater supply. Additional groundwater wells would be constructed in the SVWD groundwater basin for pumping water back to SCWD during severe drought periods. If 20 MG per month were delivered to SVWD during the winter and spring months of most years and 70 MG/month delivered to SCWD from April to October (or a portion thereof) of critical periods, the intertie program would considerably reduce the frequency and magnitude of supply deficiencies in the SCWD system. Although the cost of constructing the groundwater wells and conveyance

facilities would be relatively high, the resulting unit costs for producing this extra yield would be only $402 to $463 per MG.

Although the physical components for a successful conjunctive use intertie program appear to be available, there are many environmental, institutional and political issues that would have to be resolved before this alternative could be implemented.

8.7.11 Alternative 9 - Direct Diversion on Zayante Creek

A preliminary analysis of the available direct diversions from Zayante Creek indicated that a direct diversion on Zayante Creek would not increase the capability of the SCWD supply system in meeting drought year demands. In drought years when additional supplies are needed, little or no streamflow would be available after providing for in-stream requirements. Additionally, any diversions from Zayante Creek would cause a corresponding decrease in flow at the SLR-Tait Street diversion. In fact, if the in-stream release requirements given in the COUNTY MP were used, no diversions would be available for conditions experienced from April 1975 through November 1978. Although the in-stream requirements stipulated in the COUNTY MP may be overstated, a direct surface water diversion from Zayante Creek does not appear feasible. Therefore, operations studies and cost analyses were not conducted for this alternative.

8.7.12 Alternative 10 - Parallel Coast Pipeline

Adding a parallel pipeline in the upper reaches of the Coast Pipeline would provide the same function as installing pump stations in the North Coast supplies (Alternative 3) in that the hydraulic capacity for the North Coast would be increased under each of these alternatives. Because the same principles apply as those discussed in Alternative 3, separate operations studies were not performed for Alternative 10. As discussed earlier, increasing the capacity of the Coast Pipeline would not significantly increase the capability of the SCWD system to meet drought year demands because the increased capacity is of no benefit during critical drought periods.

8.7.13 Alternative 11 - North Coast Reservoir

In conjunction with the upgraded existing supply system (Alternative 1), construction of a major surface water reservoir in the North Coast area could eliminate all supply deficiencies for the year 2005 high growth scenario used in these operations studies. If no other major water supply facilities are constructed, the reservoir would have to be large enough to provide the entire supply deficiency projected for the 1976-77 drought under Alternative 1, about 2000 MG or 6000 AF (slightly smaller than Loch Lomond Reservoir).

Because the specific location of such a reservoir is not known at this time, the conceptual plan derived in this study was based on use of the existing

Coast Pipeline to convey water to SCWD's GHWTP. Due to the pipeline hydraulic capacity limitations, a minor supply deficiency is shown in Tables 8-4, 8-9, and 8-10 for this alternative. Additional pipelines or pump stations would be needed to increase the conveyance capacity in order to completely eliminate supply deficiencies.

Estimates for this alternative indicate that the construction cost of the reservoir and appurtenant structures would be on the order of $15 million. Although the reservoir would clearly be highly effective in reducing supply deficiencies, the unit cost for this alternative is estimated to be about $1100 to $1300 per MG. These costs do not include the potential impact of mitigation measures for adverse environmental impacts on the fishery habitat and coastal wetland areas associated with this alternative.

8.7.14 Alternative 12 - Upper San Lorenzo River Reservoir

Construction of a sufficiently large reservoir in the upper reaches of the SLR watershed also could eliminate all water supply deficiencies under the year 2005 high growth demand projected for the SCWD service area. If no other major water supply facilities are constructed, the reservoir would have to be large enough to provide the entire supply deficiency projected for the 1976-77 drought under Alternative 1, about 2000 MG or 6000 AF. Assuming the water would be conveyed through natural stream channels to avoid the cost of a lengthy pipeline, additional storage and releases would have to be provided in order to make up for water lost to seepage along the channel conveyance. After selection of a specific site, infiltration studies would have to be conducted to accurately estimate these seepage losses.

For the purpose of cost estimating, a dam site near Waterman Gap on the upper end of the SLR was chosen. Because of a more advantageous damsite than those used for the North Coast Reservoir, the cost for this alternative has been estimated at about $10 million. If the Waterman Gap site is not used, this cost could increase considerably. Therefore, the unit costs of about $600 to 800 per MG determined for this alternative must be considered preliminary. As for Alternative 11, several major adverse environmental impacts would be associated with construction of this new reservoir and would have to be evaluated before confirming the feasibility of this alternative.

8.8 SPECIAL ANALYSES

8.8.1 Introduction

In reviewing the preliminary results of the operations studies with SCWD staff and the Technical Advisory Committee (TAC), concerns were expressed about the validity of the assumptions regarding "down times" and the sensitivity of the results to the accuracy of other assumptions and data used in development of the Operations Model. Most of the concerns are believed to

be related to the "unexpected" results of the operations studies, which indicated that the existing supply system (with certain upgrades) could meet future demands in most years. Due to recent experience, many individuals may have expected results which would lead to the conclusion that the existing system is unable to even meet current demands in many instances.

To further clarify and support the results of the operations studies, several special analyses were conducted. The findings of these special analyses are discussed in the following subsections.

8.8.2 System Performance Under Low Growth Demand Scenario

In reviewing the results of the operations studies presented in previous sections, it is vital to recognize that the SCWD supply system was tested under the high growth scenario for year 2005 demand projections. This scenario is intended to represent the higher end of potential increases in water demands and, as such, assumes development of certain greenbelt areas and conservative estimates for the impacts of conservation measures on the water use for future development. Because demands will continue to increase after 2005, it was felt that use of the high growth scenario would be prudent.

To illustrate the demand assumption's impact on the results of the operations studies, Alternative 1 was also analyzed under the low growth demand scenario, which has a total demand about 6 percent less than for the high growth scenario. The operations studies for the low growth scenario indicated that maximum conservation reductions of 14 and 34 percent would be necessary in 1976 and 1977, respectively, compared to 24 and 41 percent under the high growth demand scenario. Perhaps more significant is the fact that no other supply deficiencies would occur under the low growth demand scenario. In addition to 1976 and 1977, five other deficient years out of the 66-year study period were found under the high growth scenario.

Therefore, it can be concluded that the required conservation percentage in a given year for the low growth scenario is roughly 7 to 10 percentage points lower than for the high growth scenario under Alternative 1. Similar reductions in required conservation percentages should be expected for the other alternatives. Furthermore, the frequency of supply deficiencies would significantly decrease in relation to the high growth demand scenario.

8.8.3 Sensitivity Analysis

Many of the parameters used in the Operations Model were based on estimates or correlations with other data and, therefore, contain some error. Also, concerns over the assumed "down times" were expressed. The "down times" represent the percentage of time each key production facility is assumed inoperable due to scheduled or unscheduled repairs and maintenance. After discussions with SCWD staff, down times were estimated at 2 to 10 percent.

To test the sensitivity of the assumptions and accuracy of the input data, the operational yield analysis for Alternative 1 was performed with 250 MG artificially extracted from Loch Lomond Reservoir in March of each year, except in drought years when supply deficiencies were already projected. This analysis was designed to test several possible scenarios:

(1) loss of a key production facility for an extended period of time (e.g., losing the 12 CFS available at Tait Street for about 3 months);

(2) operational problems or unscheduled maintenance (i.e., higher down times) which requires extensive use of Loch Lomond Reservoir instead of other supplies;

(3) overestimated values of the total stream runoff, hydraulic capacities, and associated "available diversions" used in the Operations Model; and/or

(4) underestimated water demands.

Results of this analysis indicated that no additional supply deficiencies would occur in the study period. There is sufficient redundancy or "backup" supplies in most years to overcome the possibilities outlined above. Supply deficiencies in drought years under the original analyses obviously would become more critical if any of the above scenarios occurred.

The results of this analysis underscore the need to develop additional supplies which will contribute to the system yield during drought years. There is adequate redundancy in the supply system to overcome operational problems in most other years. Because its capacity is relatively small in relation to its watershed's runoff, Loch Lomond Reservoir is quite "resilient" in that it will fill naturally most of the time even if large quantities of water were withdrawn the previous summer. The SCWD supply system's resiliency and relative insensitivity to all but extreme drought years can also be partially explained by reviewing the available diversion quantities from the SLR-Tait Street diverion during historical dry years. Table 8-12 shows the estimated streamflows on July 1 and September 1 of the 22 driest years between 1937 and 1986 and the estimated loss of production due to inadequate (i.e., below the 12.2 CFS diversion capacity) streamflow. This table indicates that this difference between runoff and production capacity, or "lost" production, is extremely large in the most critical drought years such as 1977 but quickly drops off by several hundred MG in most other dry years. As shown in the table, the "Estimated Loss of Production in April-October" for the four driest years is two to three times higher than for other dry years. Therefore, this diversion is relatively unaffected by hydrologic conditions except for extremely dry years. This phenomenon partially explains the relative insensitivity of the SCWD supply system to hydrologic conditions.

Table 8-12

City of Santa Cruz Water Department
Water Master Plan

AVAILABILITY OF TAIT STREET DIVERSION IN DRY YEARS

RANK 1/	WATER YEAR	RAINFALL AT WRIGHTS GAGE (Inches)	ESTIMATED MEAN DAILY FLOW (CFS) SAN LORENZO RIVER AT TAIT STREET JUL 1	SEP 1	ESTIMATED LOSS OF PRODUCTION IN APR-OCT 2/ (MG)
1	1977	17.8	7.00	5.90	608
2	1976	19.2	7.30	7.60	310
3	1972	24.9	10.50	7.50	284
4	1961	26.8	10.50	7.20	336
5	1939	27.3	7.28	8.73	201
6	1960	27.6	13.75	10.31	130
7	1964	27.7	13.75	12.45	116
8	1966	29.2	14.40	9.85	130
9	1981	29.7	12.45	8.80	188
10	1947	30.3	14.70	10.29	144
11	1985	32.1	16.35	11.15	131
12	1950	34.1	15.96	11.55	75
13	1949	35.3	17.85	12.81	57
14	1968	35.8	13.75	11.80	75
15	1979	36.4	18.30	14.40	103
16	1984	37.0	20.90	13.75	82
17	1948	37.3	20.37	11.55	205
18	1944	37.6	19.11	14.70	82
19	1955	37.8	20.37	12.18	64
20	1957	38.1	27.31	14.07	254
21	1946	39.7	21.00	13.44	81
22	1971	40.0	21.55	11.15	78

1/ Water years are ranked by ascending values of annual rainfall at Wrights gage. Only those years with less than 40 inches of rainfall are shown.

2/ Loss of production is primarily due to inadequate streamflow; however, storms in April and May due to excessive turbidity is also included. The majority of the production loss in years such as 1948 and 1957 is due to storms in April and May, not inadequate streamflow.

TAIT-DRY.WK1/F796-03-JMK-7

8.8.4 Rainfall Analysis

Within the last 12 years, the SCWD has had to ration supplies once and nearly had to impose rationing a second time in 1988. These experiences could lead to the conclusion that the supply system is inadequate to meet normal demands since shortages occurred twice within a short time span. However, investigation of rainfall records indicate that the 1976-77 and 1987-88 periods appear to be the two worst two-year droughts in the last 90 years, certainly within the last 70 years. Furthermore, the 1976-77 drought was by far the most severe drought experienced in at least the past 90 years. Therefore, unless the "greenhouse effect" is believed to have substantially altered hydrologic patterns, the two recent two-year droughts are probably a statistical coincidence and the 1976-77 drought should be considered an extremely rare event.

Within the 1921-86 hydrologic period, rainfall records at the Wrights gage (located at elevation 1600 feet in the Santa Cruz mountains about 2 miles southeast of Holy City) indicate that the occurrence of severe two-year droughts was limited to the 1976-77 period only. Hydrologic conditions for a longer period were determined using the rainfall record from a gage in the City of Santa Cruz. Records for this station are available for the period from January 1878 to the present. Although this location receives far less rainfall than the Wrights gage, the pattern of annual rainfall can be used as a general indicator of the relative dryness of each year.

A list of the driest years of record at both rainfall stations is given in Table 8-13. The streamflow at the SLR at Big Trees gage and for Newell Creek inflow to Loch Lomond Reservoir were included for comparison. The upper portion of Table 8-13 indicates that the driest single year of record is 1924 in which 16 inches of rainfall occurred. The second and third driest years were 1977 and 1976 with 18 and 19 inches of rainfall, respectively. During this period, the <u>total</u> <u>1976-77</u> runoff at the SLR gage was only 7700 MG, much less than for any other two-year drought.

Figure 8-5 shows a plot of the 2-year drought periods between 1919 and 1988 using the Wrights gage. As indicated by the figure and Table 8-13, the 1976-77 period was by far the worst 2-year drought in the 90 years of available record. Thus, severe two-year droughts such as 1976-77 are extremely rare. Also, a severe drought lasting 3 years has never occurred during the recorded period.

8.8.5 Analysis of 1976-77 Drought

To further illustrate the differences between actual historical operations and simulated operations under the proposed operating rules and other system upgrades, a comparison of operations for the 1976-77 drought period was conducted. Actual historical operation and simulated operation using the Operations Model were compared for April 1974 through March 1978, a period in which Loch Lomond Reservoir started and ended full under both historical

Table 8-13

City of Santa Cruz Water Department
Water Master Plan

DRIEST YEARS OF RECORD
FOR 1897 - 1988 PERIOD

Rank	Single Water Year	Rainfall at Wrights Gage 1/ (inches)	Rainfall at Santa Cruz 2/ (inches)	Streamflow at San Lorenzo R. at Big Trees 3/ (MG)	Estimated Newell Creek Inflow 4/ (MG)
1	1924	16.0	10.2	8,147	314
2	1977	17.8	14.8	3,117	94
3	1976	19.2	15.4	4,564	143
4	1931	22.7	10.4	6,795	261
	1987 6/	24.7	19.3	---	---
5	1961	26.8	17.8	6,080	176
6	1929	28.4	17.6	13,860	586
7	1988 6/	28.4	15.6 5/	---	---
8	1934	39.5	18.4	16,167	627
9	1913	---	13.8	---	---
10	1898	---	14.5	---	---
11	1885	---	16.2	---	---
12	1887	---	17.6	---	---
13	1880	---	18.2	---	---
14	1917	---	18.4	---	---
15	1918	---	18.6	---	---

Rank	Consecutive 2-Year Dry Period				
1	1976 - 1977	37.0	30.2	7,681	237
2	1987 - 1988	53.0 6/	34.9 5/	---	---
3	1960 - 1961	54.5	39.2	17,442	252
4	1975 - 1976	60.5	39.7	7,680	548
5	1930 - 1931	61.8	34.3	19,961	826
6	1923 - 1924	63.2	38.3	41,333	579
7	1929 - 1930	67.5	39.5	27,026	375
8	1931 - 1932	71.2	39.9	50,732	780
9	1928 - 1929	74.4	39.6	42,909	627
10	1898 - 1899	---	37.4	---	---
11	1917 - 1918	---	37.0	---	---
12	1879 - 1880	---	39.1	---	---
13	1912 - 1913	---	34.3	---	---

1/ Gage located at Latitude 37.08', Longitude 121.57 at 1600 feet elevation.
2/ Gage located at Latitude 36.59', Longitude 122.00 at 130 feet elevation.
3/ Effect of Newell Creek Dam removed for 1961-77 flows; flow for WY 1921-36 were synthesized from Arroyo Seco Soledad gage. Prior to 1921, no streamflow data were available.
4/ Estimated from Zayante Creek flows.
5/ WY 1988 through March 31.
6/ 1987 & 1988 rainfall estimated from Loch Lomond Watershed.

DRY-YR.WK1/F796-04-RJM-2

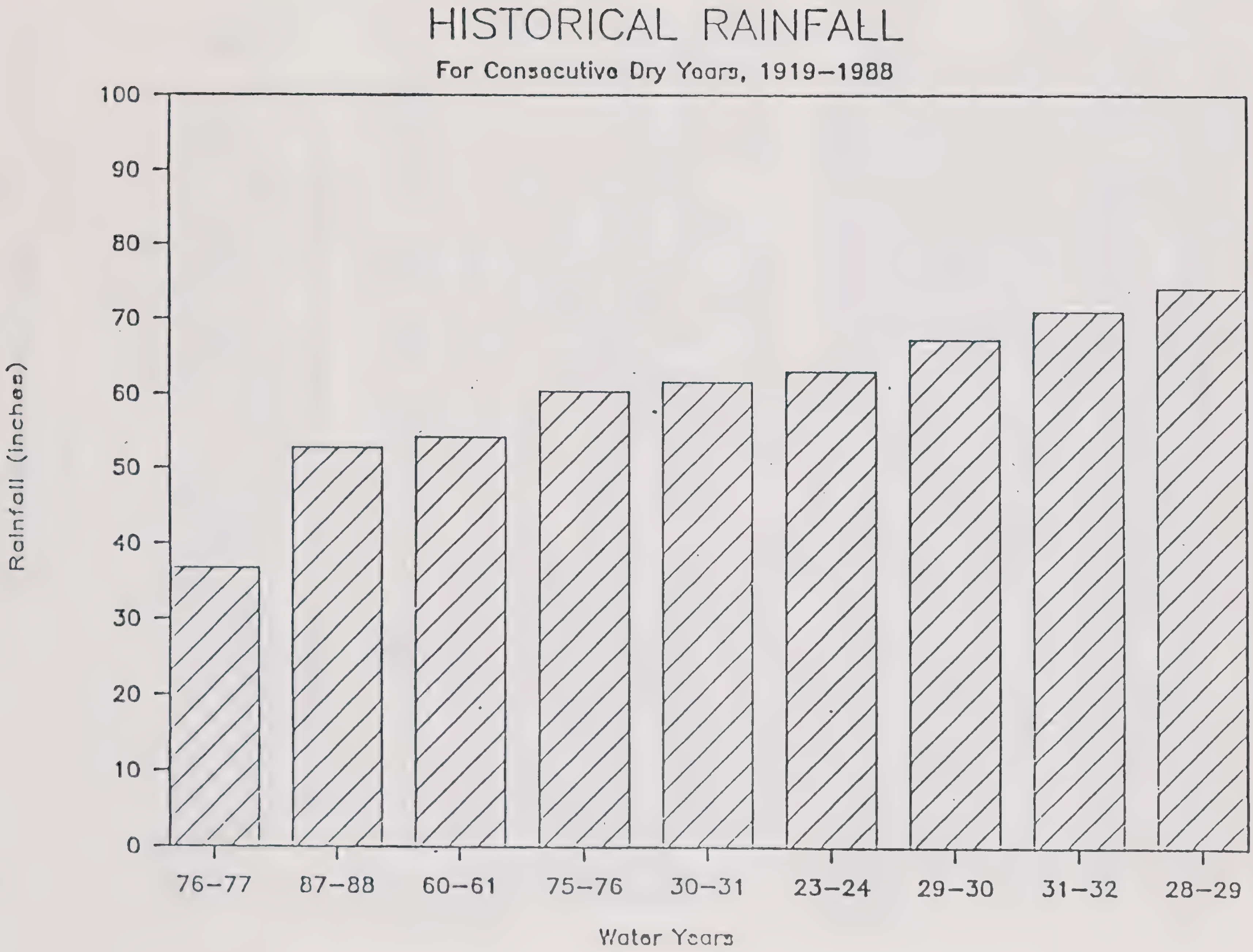
HISTORICAL RAINFALL
For Consecutive Dry Years, 1919–1988
Rainfall (inches)
100
90
80
70
60
50
40
30
20
10
0
76–77
87–88
60–61
75–76
30–31
23–24
29–30
31–32
28–29
Water Years

FIGURE 8–5

and simulated operations. Also, the actual historical demands were used in both cases. These assumptions ensure an equitable comparison.

The quantities of water produced from each supply source are tabulated in Table 8-14 for the two different operational scenarios. These results indicate that significantly more water was withdrawn from Loch Lomond under historical operations than under simulated operations, particularly during the April 1974 to October 1975 period preceeding the actual drought. Because of this, storage in Loch Lomond at the start of 1976 was about 1200 MG less than computed in the simulated operation. In effect, Loch Lomond Reservoir was already "low" before the 1976-77 drought occurred. This explains the need for the strict rationing program which SCWD had to implement in order to balance available supplies and demand during the 1976-77 drought. Under simulated operations, Loch Lomond Reservoir was nearly full prior to the drought and, therefore, the actual demands (reduced by rationing) could be met with Loch Lomond retaining almost 65 percent of its storage capacity. Further analysis indicated that little or no conservation would have been necessary in the 1976-77 drought if the system upgrades (Alternative 1) included in the simulation studies were in place. The reservoir levels for the 1974 to 1978 period under both historical and simulated operations (with the actual demand) are shown on Figure 8-6.

The major differences in reservoir levels between historical and simulated operations are primarily due to a considerable amount of "lost" production from the SLR-Tait Street diversion. Under historical operations, the SLR-Tait Street diversion was out of service for much of this critical period, apparently caused by electrical problems with the pumps. Review of historical production records indicated that no water was produced from the SLR-Tait Street surface diversion for seven months of this critical period and production in other months was severely curtailed. Table 8-14 shows that approximately 1800 MG, most of which had to be taken out of Loch Lomond, was "lost" at this diversion prior to the actual drought. Based on the assumed 2 MGD capacity, production from the Beltz wells was also significantly higher under simulated operations. Also, due to higher turbidity limits for simulated operations, diversions from the North Coast in the model are approximately 25 percent higher during the 1974 to 1978 period.

This analysis helps explain the significant impact which the proposed operating rules and assumed system upgrades should have on the SCWD supply system.

8.8.6 Comparison of Safe Yield Estimates to COUNTY MP

The results of the firm or safe yield analyses for Alternative 1 (upgraded existing system) were also compared to the estimated safe yield values reported in the COUNTY MP. Table 8-15 lists for each water supply source the estimated safe yields determined in this SCWD master plan study and in the COUNTY MP.

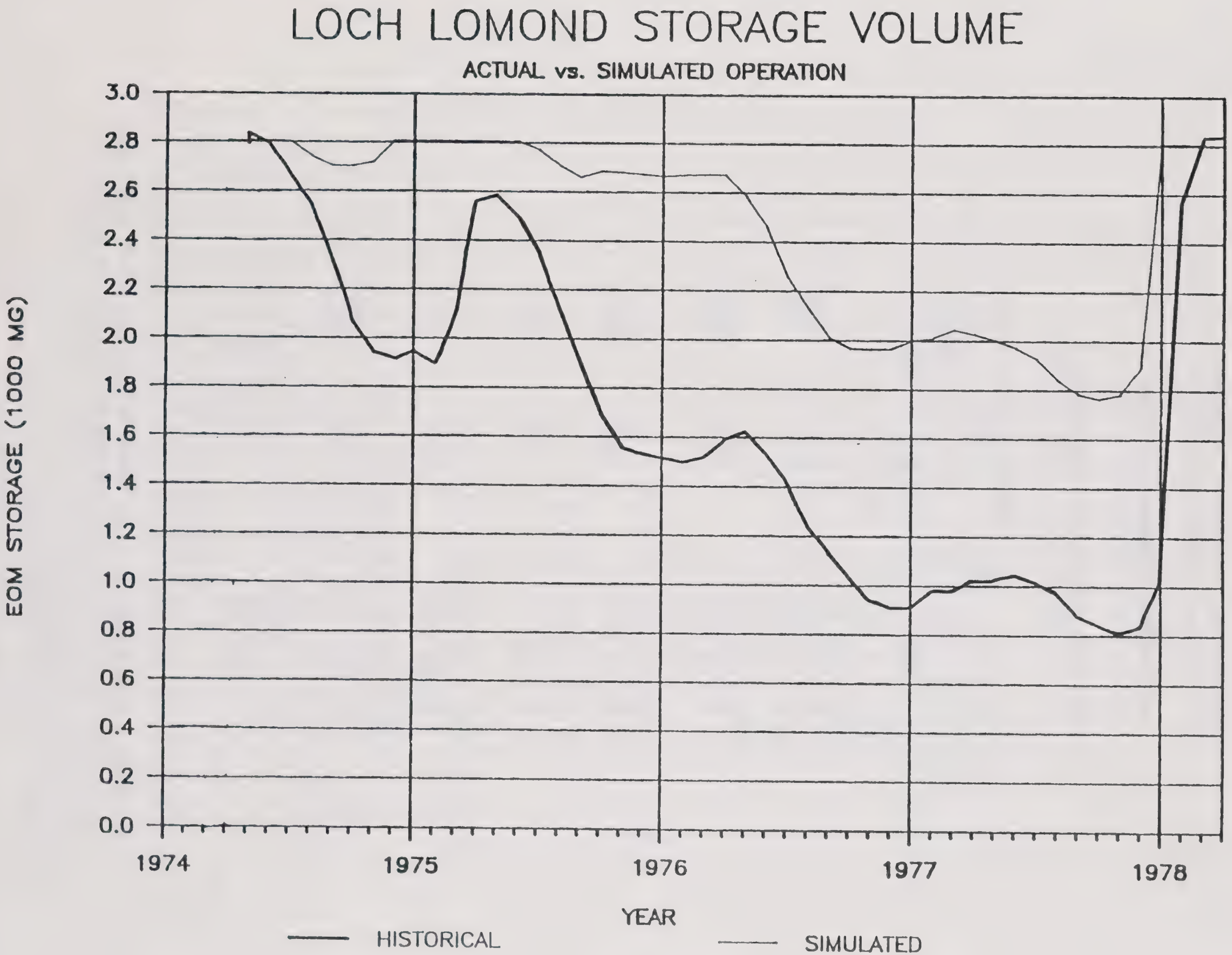
LOCH LOMOND STORAGE VOLUME
ACTUAL vs. SIMULATED OPERATION
EOM STORAGE (1000 MG)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1974
1975
1976
1977
1978
YEAR
HISTORICAL
SIMULATED

FIGURE 8-6

Table 8-14

City of Santa Cruz Water Department
Water Master Plan

WATER SUPPLY OPERATIONS FOR
1976-1977 DROUGHT

(All values in million gallons)

Item	Operating Condition: Actual	Operating Condition: Simulated w/ Actual Demand
Total Demand		
4/74-10/75	6781	6781
11/75-3/78	8090	8090
Coast Production		
4/74-10/75	2041	2572
11/75-3/78 1/	1743	2120
SLR Production 2/		
4/74-10/75	1500	3292
11/75-3/78	4493	4236
Beltz Wells Production		
4/74-10/75	269	431
11/75-3/78	314	528
Loch Lomond Withdrawls 3/		
4/74-10/75	2745	116
11/75-3/78	1124	640
Fish Releases		
4/74-10/75	227	371
11/75-3/78	415	566
Felton Diversion		
4/74-10/75	0	0
11/75-3/78	398	77

1/ 11/75-9/77 production is only about 40% higher under simulated conditions; about 60% of differences attributed to 10/77-3/78 period when higher turbidity constraint becomes effective.
2/ Includes Tait Street Wells.
3/ Does not include fish releases.

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Table 8-15

City of Santa Cruz Water Department
Water Master Plan

SAFE YIELD OF SCWD EXISTING WATER SUPPLY SOURCES
(Million gallons per year)

SOURCE	1988 CITY MP 1/	1985 COUNTY MP	DIFFERENCE
North Coast	750	520 2/	230
San Lorenzo River Tait St. Diversion	2,160 3/	1,800 2/	360
Beltz Wells	380	860 4/	(480)
Loch Lomond Reservoir	950 5/	490 2/	350 6/
Felton Diversion	---	110 2/	---
TOTAL	4,240	3,780	460

1/ Breakdown is for WY 1976-1977 from firm yield analysis.
2/ Values taken for 98.4% exceedance shown in Figures A-2 through A-4 of Subtask D-1 Report; Laguna and Tait Street have been adjusted as indicated in the footnotes for these figures. The total for the surface water sources does not match the 2880 MG/YR (8850 AF/YR) indicated in COUNTY MP.
3/ Includes Tait Street Wells.
4/ Includes Tait Street Wells; taken from page 36 of Subtask D-1 Report.
5/ Includes the impact of Felton Diversion.
6/ Includes COUNTY MP's 110 MG/YR "yield" for Felton Diversion.

FILE: COUNTY.WK1; DISK: F796-03-JMK-41

Because a detailed investigation of the SCWD water supply system was not included in the COUNTY MP study, the safe yield estimates developed in the COUNTY MP were primarily based on theoretical frequency analyses and actual production during the 1976-77 drought. The results of the theoretical frequency analyses were adjusted for the SLR-Tait Street and Laguna Creek diversions to match actual production in 1976-77. Therefore, the reported safe yield for these two sources were essentially based solely on actual conditions during the 1976-77 drought.

As reported on page 34 of the COUNTY MP Subtask D-1 report and Table 2 of the final report, the composite safe yield from all surface water sources was reported to be 8850 AF/YR or 2880 MG/YR. An additional 2630 AF/YR or 860 MG/YR of "drought managed yield" was included for the Beltz wells. Therefore, the total safe yield reported in the COUNTY MP for the existing SCWD supply system (i.e., without the additional groundwater development assumed) was 11,480 AF/YR or 3740 MG/YR.

Because a separate breakdown of the safe yield for the surface water sources was not provided, the methodology and frequency curves given in the Subtask D-1 report were used to determine the COUNTY MP's estimates of safe yield for the individual surface water sources. This procedure resulted in the individual estimates shown in Table 8-15. These estimates would provide a safe yield of surface water sources of 8965 AF/YR (2920 MG/YR), slightly higher than the 8850 AF/YR value reported in the COUNTY MP. This discrepancy cannot be explained by the data supplied in the COUNTY MP reports.

Comparison of the individual estimates in Table 8-15 reveals significant differences in the results of the two studies. For example, the safe yield of all surface water sources was estimated to be 3860 MG/YR in this SCWD master plan study versus a corresponding total of about 2920 MG/YR from the COUNTY MP. The apparent reasons for these dramatic differences are as follows:

(1) The operational interactions between the various sources were not considered in the COUNTY MP. Therefore, the COUNTY MP's estimate of Loch Lomond Reservoir's contribution to the safe yield was based solely on a streamflow frequency analysis. When actual operations are considered, the reservoir can supply considerably more water during the critical year than indicated by a theoretical frequency analysis independent of system operations.

(2) As explained in the previous section, major outages at the SLR-Tait Street surface diversion during the 1976-77 drought caused significant "losses" in production. Therefore, the COUNTY MP's use of actual production during this period as the safe yield of this source underestimated the safe yield.

(3) The higher turbidity limits on the North Coast diversions were not considered in the COUNTY MP. Also, the hydraulic capacities used

for the North Coast sources in the COUNTY MP are slightly less than those computed and used in this study. Use of synthesized streamflow data in this study may also have slightly overestimated the available runoff.

Because the Felton Diversion cannot generate a safe yield on its own, its contribution to the overall safe yield should be included under Loch Lomond Reservoir.

The large differences in groundwater production offset a portion of the differences in the safe yield of surface water sources. Again, because actual operations were not considered, the COUNTY MP study indicated a significantly higher yield (860 MG/YR versus 380 MG/YR) for the Beltz wells. Although such a yield may be available if the wells were operated independently, the actual contribution of the Beltz wells to the overall safe yield would be closer to 380 MG/YR <u>under the proposed operating rules</u>.

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Chapter 9

PROPOSED IMPROVEMENTS

9.1 GENERAL

The improvements proposed for the SCWD water system over the next 15 years are summarized in this chapter. The distribution system improvements presented in Chapter 3 are summarized in Section 9.2. As described in Chapter 5, the existing treatment facilities are able to meet all the current standards and no specific improvements have been proposed for water treatment facilities due to the uncertain nature of incoming drinking water standards.

The proposed alternatives for development of additional water supplies are presented in Section 9.3. Other related improvements or studies, including the recommended alternative for providing North Coast domestic service, are also presented in Section 9.3. A summary of the recommended improvements, including suggested priority levels (1 being the highest) and estimated implementation dates, is given in Table 9-1.

9.2 DISTRIBUTION SYSTEM

9.2.1 Distribution Mains

The primary distribution system improvements that are proposed to serve future development are primary distribution pipelines. Installation of these pipelines will help to alleviate low pressure and flow distribution problems that would otherwise arise as growth occurs.

The recommended pipeline installations are listed in Table 9-1. Although all of these pipelines will be needed as development occurs, certain improvements which are most critical have been assigned a higher priority. Because the precise pattern and timing of future development is not known, the implementation date for all distribution mains has been assumed to be year 2000. In reality, these pipelines will be staggered over a 10 to 15 year period as specific development occurs.

The total estimated cost in 1988 dollars for the distribution main improvements is $870,000.

9.2.2 Pumping Stations

Three pumping stations are proposed for expansion and upgrade of the UCSC system in order to meet projected demands. These pumping stations include University Pumping Stations #2, #4, and #6. The proposed improvements are projected to be needed within the next 10 years. The cost for these modifications is estimated to be about $25,000 per station. A new 200 GPM pumping

Table 9-1

City of Santa Cruz Water Department
Water Master Plan

PROPOSED IMPROVEMENTS
(1988 Dollars)

DESCRIPTION	PRIORITY LEVEL	ASSUMED IMPLEMENTATION DATE	ESTIMATED PROJECT COST
DISTRIBUTION SYSTEM			
1. 12" along King, Bay to Escalona	2	2000	$137,000
2. 12" along Mission, Bay to Baldwin	2	2000	$52,000
3. 12" along Water, May to Morrissey	1	2000	$204,000
4. 14" along Soquel Ave, 7th to Mattison	1	2000	$273,000
5. 12" along Soquel Ave, Mattison to 41st	1	2000	$168,000
6. 8" along Mattison, Soquel Ave to Maciel	2	2000	$65,000
7. 12" Delaveaga Reservoir to Mission & Twin Hills	1	2000	$168,000
8. 10" Mission & Twin Hills to Soquel Drive	1	2000	$84,000
9. 12" along Soquel Drive, Mission to Thurber	1	2000	$37,000
10. 10" along Soquel Drive, Thurber to Chanticleer	1	2000	$14,000
11. Expand/Upgrade University Pumping Station #4	1	1989	$34,000
12. Expand/Upgrade University Pumping Station #2	1	1992	$34,000
13. Expand/Upgrade University Pumping Station #6	1	1995	$34,000
14. New 0.4 MG University Reservoir	2	2000	$828,000
15. New 200 GPM University Pumping Station	1	2000	$69,000
NORTH COAST			
16. Domestic Service Line and Storage Tank	1	1990	$722,000
SUPPLY PRODUCTION SYSTEM			
17. Thurber Lane Wells and Treatment Plant	1	1989	$958,000
18. Harvey West Well	1	1990	$95,000
19. Felton Booster Station - Additional Pumps	2	2000	$369,000
20. Felton Diversion - Variable Speed Drive	2	1995	$105,000
21. Wastewater Reclamation	2	1995	$683,000
22. SVWD Intertie	2	1995	$2,791,000
23. Raise Newell Creek Dam 4 feet	2	1995	$440,000
24. Dam and Reservoir - North Coast or SLR 1/	2	2000	$15,000,000
25. Tait Street Wells Rehabilitation	2	1990	$100,000
26. Newell Creek Stream Gage	3	1992	$142,000
27. Laguna Creek Stream Gage	3	1992	$142,000
OPERATIONS & MAINTENANCE			
28. Proposed Operating Rules	1	1989	N/A
29. Additional Maintenance at Key Facilities	1	1989	$90,000
ADMINISTRATION			
30. Fee Schedule - Section I Modifications	3	1989	N/A
ADDITIONAL STUDIES			
31. Newell Creek Dam - Parapet Wall	N/A	1990	$150,000
32. Scotts Valley Wastewater Reclamation Program	N/A	1990	$150-200,000
33. Scotts Valley Intertie	N/A	1990	$200-300,000
34. Felton Diversion/Newell Creek Pipeline Capacity	N/A	1990	$10,000
35. New Dam and Reservoir Feasibility	N/A	1990	$300-400,000
36. Environmental Analysis and EIR	N/A	1993	$100-500,000
37. Loch Lomond Reservoir Sedimentation	N/A	1990	$20-50,000
38. Misc. Water Quality and Treatment Studies	N/A	1990	$400-500,000

1/ Construction of a 6,000 to 8,000 AF reservoir may eliminate need for other water supply alternatives such as Wastewater Reclamation, SVWD Intertie, and Raising Newell Creek Dam. Indicated cost is for North Coast alternative on Baldwin Creek.

station is also recommended for the UCSC system for the year 2000. The cost for its installation is estimated to be $50,000.

9.2.3 Storage Reservoirs

A storage reservoir with 0.4 MG capacity is recommended to be installed in the UCSC area by the year 2000. The cost of this reservoir is estimated to be $600,000. No other distribution system reservoirs are proposed.

9.3 WATER SUPPLY SYSTEM

9.3.1 Water Supply Development

Numerous alternatives were identified and evaluated during the course of this study for developing additional water supplies for the SCWD service area. Descriptions of these alternatives are presented in Chapter 7 and evaluations of the viable alternatives are presented in Chapter 8.

Based on the knowledge of and familiarity with the SCWD water supply system obtained during this study, two basic alternative courses of action for development of adequate water supplies to serve anticipated demands through year 2005 have been identified for consideration by the City Council and the SCWD:

(1) The existing water supply system will be "upgraded" in the near future as explained under Alternative 1. The only major facility required as part of this upgrade is construction of the recommended alternative for providing North Coast domestic service. As described in Chapter 6, a small-diameter, parallel pipeline should be constructed along the existing Coast Pipeline in order to provide domestic service within federal and state drinking water standards.

With only the proposed operating rules, increased use of North Coast supplies due to higher turbidity limits (by removing domestic services), and increased use of the Beltz wells, the existing sources and facilities of the SCWD supply system will be marginally adequate to meet the projected demand in year 2005. As shown in Tables 8-4 and 8-9, supply deficiencies would occur about 10 percent of all years. However, most of these deficiencies would be quite small, likely requiring only voluntary conservation through a public information program. Large reductions in demand through mandatory rationing should only be needed during rare, extremely severe two-year droughts such as that experienced in 1976-77. <u>The determination of whether or not this level of service is considered adequate is highly subjective and, therefore, cannot be definitively answered</u>.

The water supply alternatives involving expanded or optimized use of existing sources of supply (Alternatives 2 through 10) could significantly reduce both the frequency and magnitude of supply deficiencies

within the SCWD system. Several of these alternatives were determined to be cost-effective means of developing additional drought-year yield. Certain combinations of these alternatives could eliminate all supply deficiencies except in the most severe two-year droughts such as 1976-77. Although deficiencies would still occur in such droughts, the required level of conservation is expected to be less than 30 percent in the most critical drought year.

Because there are still many uncertainties associated with several of the alternatives, a specific implementation plan is difficult to develop. However, based on the unit costs shown in Table 8-10 and consideration of other factors, the following water supply alternatives involving existing sources should be pursued in the following order of priority:

- Alternatives 5A & 5B - Additional Groundwater Wells (Thurber Lane and Harvey West Park)
- Alternative 7A <u>or</u> 7B - Enlarge Loch Lomond Reservoir
- Alternative 8A - Scotts Valley Intertie
- Alternative 2B - Reduce Operating Margin at Felton Diversion
- Alternative 6 - Wastewater Reclamation

The total cost for constructing all of the above alternatives (using Alternative 7A over 7B) would be about $4 million, almost half of which is attributed to the Scotts Valley Intertie. The recommended alternative for the North Coast domestic service would cost an additional $700,000 to construct. The remaining alternatives should not be considered for development of additional drought-year yield. However, some plans such as Alternatives 3 and 4 may present sufficient other "operational" advantages to warrant further consideration.

As noted above, supply deficiencies will still occur in severe droughts even after implementation of one or more of the alternatives listed above. Therefore, the use of "demand management" will be necessary on rare occasions. "Demand management" is becoming a more common means of planning for water supply agencies. These agencies are now recognizing that the economic and environmental costs of developing additional supplies may offset the "cost" of requiring customers to reduce water consumption during drought periods, whether voluntarily or involuntarily. Therefore, some agencies are now accepting the fact that occasional supply deficiencies will occur and "demand management" must be used in such instances in lieu of developing additional sources of water supply. The City Council of the City of Santa Cruz and the SCWD must decide whether occasional supply deficiencies are acceptable and, if

so, what frequency and/or magnitude of deficiencies should be considered acceptable in future water supply planning.

(2) If water supply deficiencies are considered unacceptable even during severe drought periods, a major new surface water reservoir will be required. Two alternative concepts were investigated in this study for construction of a new reservoir. If the City Council elected to pursue such a plan, only the lowest-cost alternatives presented in (1) above should be implemented.

Due to major opposition from environmentalist groups, construction of a major new reservoir would be difficult and costly. Based on a preliminary conceptual plan, the construction cost for a major new dam and reservoir would be at least $10 to $15 million. However, such a reservoir would minimize or eliminate the possibility of supply deficiencies even under severe droughts such as 1976-77. Additional investigations would be required to identify the best location and optimal size of a major new reservoir.

The value of this increased level of service to the SCWD's customers must be weighed against the relatively high cost of implementing this plan.

9.3.2 Operation and Maintenance Procedures

The proposed operating rules, discussed in Section 8.3.4 and explained in the separately bound Operations Manual, should be adopted and closely followed. These rules are designed for optimal use of the existing SCWD sources and facilities. <u>If major new facilities are added, these rules should be reviewed and adjusted.</u>

Maintenance procedures and inventory should be closely monitored to ensure that key production facilities are not out of service for extended periods. During drought years, all key production facilities must remain operational over 95 percent of the time in order to realize the yields documented in this report.

9.3.3 Other Improvements and Studies

During the course of this study, the need for other miscellaneous improvements and further studies was identified. As indicated in Table 9-1, the following improvements and studies are recommended:

(1) <u>Rehabilitation of Tait Street Wells</u> - The rehabilitation plans for the Tait Street wells should be carried out. These wells are important in sustaining the full capacity of the SLR-Tait Street diversion and can be used in lieu of withdrawals from Loch Lomond Reservoir during periods of excessive turbidity on the surface water sources.

(2) Groundwater Investigations - As evidenced by the significant increase in firm yield and the low unit cost for Alternative 5, additional groundwater resources are an extremely effective means of developing additional supplies for the SCWD service area. Additional groundwater wells are normally able to provide their full capacity during drought periods, do not significantly impact the environment, and are relatively low in cost. Therefore, the SCWD should continue an aggressive program of groundwater investigation.

(3) Streamflow Gages - Additional streamflow data, particularly on Laguna Creek, will provide valuable information to future hydrologic studies of the SCWD supply system. Therefore, construction and operation of streamflow measuring stations is recommended on Laguna and Newell Creeks.

(4) Feasibility and Environmental Studies - As explained in various sections of this report, additional studies will be needed to further investigate the feasibility of water supply alternatives. In particular, detailed feasibility investigations of the Scotts Valley groundwater basin, the possible raising of Loch Lomond Reservoir, and construction of a major new storage reservoir, would be needed before implementing Alternatives 7A, 7B, 8A, 11, or 12. In-depth environmental studies will also be needed for the selected alternatives.

(5) Water Rights - Because the dry year yield of the SCWD supply system is heavily dependent on the availability of flow in the San Lorenzo River, the SCWD should investigate and monitor water use along the river (i.e., water rights, actual diversions, etc.). Such an assessment is critical in order to verify and safeguard the dry year capability of the SCWD system. The results presented in this study are based on historical streamflow records. SCWD should also clarify the water rights held for Felton Diversion and Newell Creek (Loch Lomond Reservoir).

(6) Loch Lomond Sedimentation - During major storms, a considerable amount of sediment is carried into the reservoir. If a significant percentage of the incoming sediment is deposited in the reservoir, the storage capacity may be considerably less than the original volume. Due to its critical role in water supply operations, the reservoir's stage-storage relationship should be verified.

(7) Water Quality and Treatment - Due to incoming changes in water quality standards, a variety of studies related to water quality and treatment should be conducted. These studies are discussed in Chapter 5.

(8) Water Rates - The existing connection charges appear adequate at this time but should be reviewed after the desired course of action for water supply development is selected. However, Section I of the SCWD's water rate schedule should be revised as explained in Section 10.5.2.

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Chapter 10

FINANCIAL ANALYSIS

10.1 BACKGROUND

Review of financial planning is commonly included in water master plan studies. Once required capital improvements are identified, the method by which the cost of improvements will be financed must be considered. Also, recent state legislation (Assembly Bill 1600) may require water purveyors to make specified findings and segregate fees for new development projects whose costs will be borne by project applicants. In effect, water utilities may have to justify the need for and extent of improvements, as well as the associated fees, to serve individual new developments.

Municipal water system rate structures are designed to provide sufficient total revenue to cover all operating costs of the utility. Rates must not only be adequate to meet normal ongoing operation and maintenance expenses but also to finance the debt incurred for construction of both existing and future major water supply facilities. Rate schedules are generally comprised of three major components:

Service Charge - a monthly or bi-monthly charge related to the fixed cost of providing water service without regard to the amount of water used or the required system capacity; costs repaid through service charges include meter reading, administration, and ongoing system maintenance.

Commodity Charge - a monthly or bi-monthly charge related to the amount of water actually used; commodity charges are intended to repay the cost of power, chemicals, water purchase costs, and other incremental costs that vary with the amount of water supplied.

Connection Charge - a one-time charge related to the cost of providing water supply facilities with adequate capacity to meet peak demands, including treatment plants, storage reservoirs, and pipelines; equitable connection charges are designed to allocate the costs for constructing facilities in proportion to the peak demand imposed on the system for which such facilities must be designed.

Because future customers normally utilize a portion of the existing system's capacity (i.e., value), connection charges may also include consideration of a "buy-in" fee for use of the existing facilities. Due to economies of scale, water system facilities are often designed to provide adequate capacity to meet anticipated water requirements for 10 to 20 years or more. Hence, future customers for which existing facilities were designed should pay a fair share of those facilities

even if the facilities were built many years before these new customers are connected to the system.

Because the service meter size is normally based on the expected peak demand of the water service, connection charges are normally proportioned to the meter size. This approach is also the only practical method from an administrative standpoint.

The purpose of the analysis described in this chapter is to allocate the costs of recommended capital improvements presented in Chapter 9 to specific areas or zones of benefit and to review connection charges for adequate and equitable repayment of costs. The other components of water rate structures, which are not directly related to master planning, are not covered in this study. All aspects of the SCWD water rate structure were investigated in detail in the "Water Rate and Fee Study" dated January 1985, hereinafter referred to as the 1985 Rate Study. However, the connection charges in the previous study were based on a capital improvement program extending only through Fiscal Year 1988-89. Therefore, the connection charges developed in the 1985 Rate Study and the SCWD's current connection charges have been reviewed in relation to the long-term capital improvement program presented in Chapter 9.

10.2 PROPOSED ZONES OF BENEFIT

Revenue generation from connection charges should be based on an equitable apportionment of the system improvements' benefits to different customers. Certain improvement projects will only benefit a limited group of customers whereas some general improvements may benefit all users. Therefore, the SCWD service area was divided into "Zones of Benefit" for use in comparing the projected revenue through connection charges from each zone with the "fair share" of project costs based on apportionment of project benefits. The criteria used to establish these zones included political boundaries, land use, hydraulics, and geographical boundaries.

In order to develop a totally equitable cost allocation system, the SCWD service area would have to be divided into numerous zones. However, due to administrative (and possibly legal) considerations, use of a large number of zones is not practical. Therefore, a system has been derived which presents relative equitability but, at the same time, reduces the administrative and legal complications.

The SCWD service area has been broken down into seven proposed "Zones of Benefit" for the purpose of equitably distributing the costs of future improvements. The seven zones are identified as follows:

Zone	Name	Boundaries 1/
1	City West	CL,UCSC,SA,Bay,Mission,& Ocean Streets, Hwy 1
2	City Central	Bay,Mission,& Ocean Streets,SLR
3	City East	SLR,Ocean St.,CL
4	Live Oak/Capitola	CL,SA
5	Pasatiempo	CL,SA
6	University	UCSC
7	North Coast	All North Coast Customers

1/ CL = City Limits
SA = "inner line" service area boundary
SLR = San Lorenzo River
UCSC = Univ. of California at Santa Cruz

The proposed boundaries for the seven zones are shown in Figure 10-1.

10.3 EXISTING CONNECTION CHARGES

As indicated in the 1985 Water Rate and Fee Study, the SCWD's existing schedule of connection charges includes consideration of a "buy-in" fee for utilizing existing facilities and the marginal cost of providing new facilities to serve incoming development. As explained above, connection charges are typically tied to the meter size. The existing connection charge for a typical residential dwelling unit is $2,735, compared with $3080 recommended in the 1985 Rate Study. The connection charge for services other than residential units increases with meter size based on a set of "capacity ratios".

In addition to the basic connection charge, Section O of the SCWD rate schedule specifies a "Zoned Capacity Fee" for new customers in the Pasatiempo/Carbonera area (similar to Zone 5). The City Council has determined that this zone received a disproportionate amount of the benefit from the construction of a new storage tank and booster pump station and, therefore, should repay that portion of the actual cost of the extension devoted to new customers. The zoned capacity fee, which acts as a surcharge to the basic connection charge, begins at $4,133.77 per connection for 1988 and increases annually to $6,018.12 in the year 2000.

10.4 ANALYSIS OF CAPITAL REPAYMENT

10.4.1 Alternative Financing Methods

There are several alternative means of acquiring financing to cover the costs of major capital improvement projects. The "pay-as-you-go" method is typically the easiest and least expensive way to finance a project; however, the use of "pay-as-you-go" is generally restricted to small scale projects. This method restricts the utility's available cash supply which, in turn, reduces its ability to meet unanticipated needs. Collecting and maintaining

large sums of cash reserves to fund major improvements is generally not prudent from a financial or equity viewpoint.

For larger scale projects, a wide variety of options involving long-term repayment are available. These options include use of bonds, certificates of participation, state or federal loans, and special assessment districts. For purposes of this study, the major capital improvements are assumed to be financed by means of a long-term repayment option, probably through certificates of participation. Therefore, connection charges will be reviewed to repay the long-term average annual cost of financing projects as opposed to providing revenue to cover the total project cost during the period of construction.

10.4.2 Allocation of Costs to Zones of Benefit

Because existing customers have already paid a connection fee and there presumably is adequate system capacity to serve them, the costs for new facilities required only to serve new development should equitably be borne entirely by the new customers through connection charges. In other words, the costs for future facilities required to provide adequate system capacity to meet increasing demands should not affect the service or commodity charges to existing customers. However, the costs of improvements needed to maintain a given level of service should be allocated to both current and future users through service and/or commodity charges.

In the 1985 Rate Study, two categories of projects were defined to allocate the costs of the capital improvements. "Expansion" projects are related to serving the needs of new development and will be funded entirely by new development through connection charges. "Upgrading" projects are needed to maintain the present level of service and will be funded through the other water rate components. Similar terminology and philosophy were applied in this study of connection charges. Since the cost of upgrading projects does not affect connection charges, only the costs of expansion projects are included in this analysis.

Based on the list of improvements shown in Table 9-1, the capital improvements identified as expansion projects and their corresponding capital costs were separated from other improvements. Upgrading projects which are not directly related to the needs of future development, such as Water Supply Alternative 1 and the recommended plan for North Coast domestic service, are not included since they would not be financed through connection charges. The operation and maintenance (O&M) portion of the total project costs shown in Table 9-1 also is not included since such costs will be repaid through other water rate components. However, the capital costs of all other improvements to both the water supply and distribution systems will be allocated to future development since there will be no significant deficiencies within the existing systems after the upgrading projects are completed.

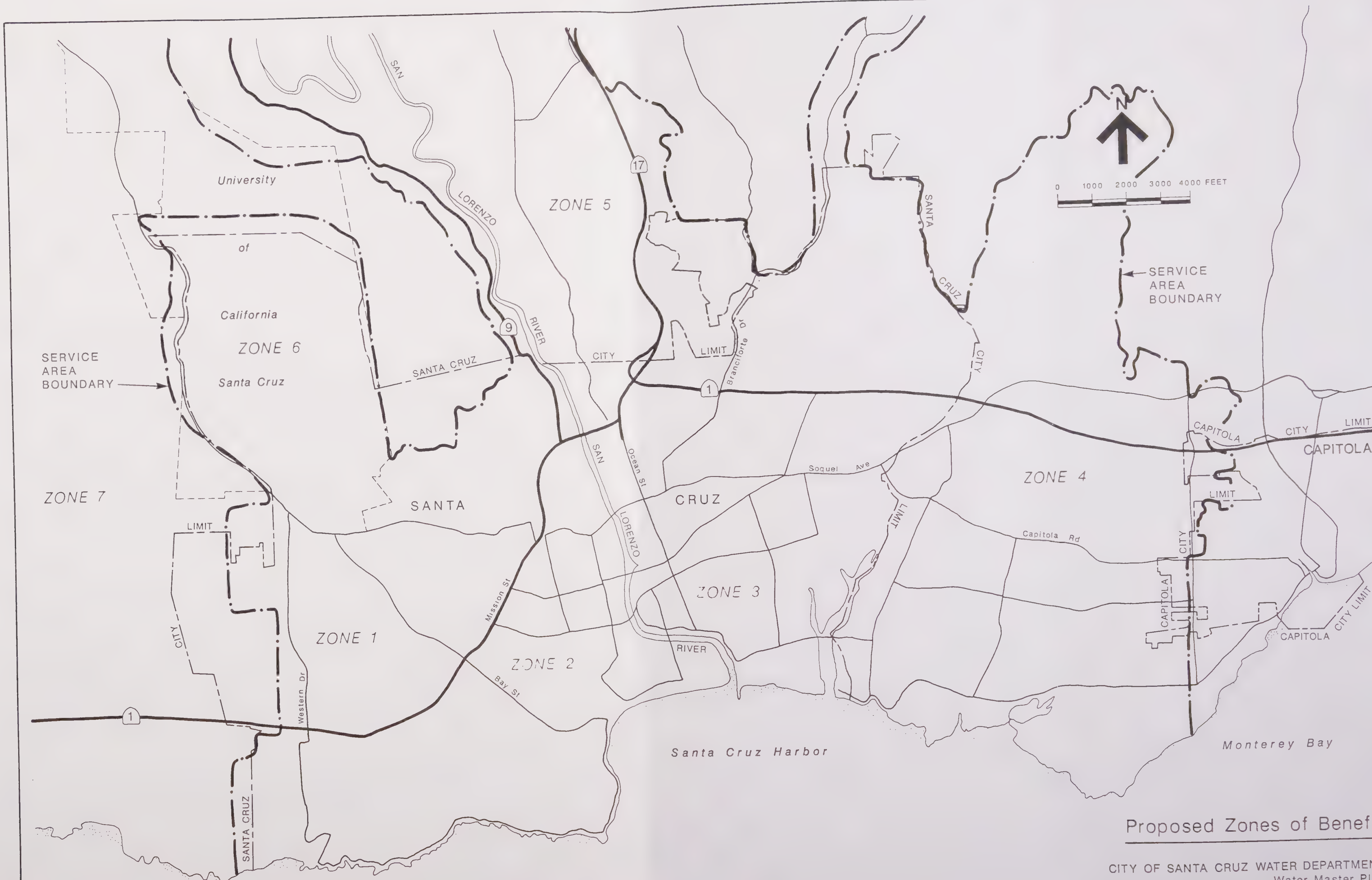
The expansion projects and their corresponding capital costs are listed in Table 10-1. These capital costs were then allocated to individual zones in proportion to the estimated percentage of the total benefit received by the individual zone. In general, the benefit of developing additional water supplies is distributed in proportion to the estimated increase in demand (i.e., growth) in each zone. The amount of growth in each zone has been approximated by the number of residential dwelling units (connections) projected for each census tract of the SCWD service area. The costs of distribution system improvements, which only affect pressures within a given area, have been distributed to those zones requiring additional capacity due to anticipated growth, primarily Zone 4 (Live Oak area) and Zone 1 (western side of City).

10.4.3 Comparison of Costs and Revenues

Based on the costs presented in Table 10-1 (distributed by zone) and an assumed 15 percent allowance for miscellaneous financing costs and bond reserve funds, a stream of annual revenue requirements was generated for each zone. Using alternative sets of connection charges and the projected number of connections in each zone, the future annual revenues from each zone can be estimated. Comparison of projected costs versus anticipated revenues indicates whether the assumed connection charges are adequate to finance future capital improvements within each zone.

Table 10-2 presents the comparison of anticipated revenues and costs on an average annual basis for two possible combinations of water supply alternatives. The current connection charge of $2735 per connection was used in both analyses. As indicated, the average annual revenues are expected to exceed the projected capital costs of the assumed improvements for the (a) combination of alternatives by roughly $700,000. Although an analysis of outstanding debt for existing facilities has not been conducted, the revenue excess would appear adequate to cover such costs. Because no major water supply facilities in the "expansion" category have been built in recent years, the amount of outstanding debt service attributable to future connections should be relatively small.

The lower set of values, the (b) combination of alternatives, in Table 10-2 is based on including a proposed North Coast Reservoir in the capital improvement program in lieu of other smaller improvements. As indicated, the projected average annual revenue under this scenario is insufficient to cover the annual costs of financing. With consideration of outstanding debt for existing facilities, the current connection fees appear inadequate for this scenario. In this analysis, however, the entire capital cost of constructing the dam and reservoir has been allocated to future development. Because the reservoir would improve the reliability, water quality, and/or cost efficiency of the entire supply system, an argument can be made for financing a portion of the total capital cost through other components of the water rate structure. If about 25 percent or more of the total capital



Proposed Zones of Benefit

CITY OF SANTA CRUZ WATER DEPARTMENT
Water Master Plan

Leedshill-Herkenhoff, Inc.
Metcalf & Eddy, Inc.
November 1988

NOTE: Service area boundaries form outer boundaries of zones.

~~Table 10-1~~

City of Santa Cruz Water Department
Water Master Plan

PROPOSED EXPANSION PROJECTS
(1988 Dollars)

DESCRIPTION	ESTIMATED CAPITAL COSTS
DISTRIBUTION SYSTEM	
ZONE 1:	
1. 12" along King, Bay to Escalona	$99,000
2. 12" along Mission, Bay to Baldwin	$38,000
ZONE 4:	
3. 12" along Water, May to Morrissey	$148,000
4. 14" along Soquel Ave, 7th to Mattison	$198,000
5. 12" along Soquel Ave, Mattison to 41st	$122,000
6. 8" along Mattison, Soquel Ave to Maciel	$47,000
7. 12" Delaveaga Reservoir to Mission & Twin Hills	$122,000
8. 10" Mission & Twin Hills to Soquel Drive	$61,000
9. 12" along Soquel Drive, Mission to Thurber	$27,000
10. 10" along Soquel Drive, Thurber to Chanticleer	$10,000
ZONE 6:	
11. Expand/Upgrade University Pumping Station #4	$25,000
12. Expand/Upgrade University Pumping Station #2	$25,000
13. Expand/Upgrade University Pumping Station #6	$25,000
14. New 0.4 MG University Reservoir	$600,000
15. New 200 GPM University Pumping Station	$50,000
SUPPLY SYSTEM	
17. Thurber Lane Wells and Treatment Plant	$585,000
18. Harvey West Well	$68,000
19. Felton Booster Station - Additional Pumps	$115,000
20. Felton Diversion - Variable Speed Drive	$54,000
21. Wastewater Reclamation	$615,000
22. SVWD Intertie	$1,825,000
23. Raise Newell Creek Dam 4 feet	$423,000
24. North Coast Reservoir 1/	$15,000,000

1/ Construction of North Coast Reservoir may eliminate need for other water supply alternatives such as Wastewater Reclamation, SVWD Intertie, and Raising Newell Creek Dam.

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Table 10-2

City of Santa Cruz Water Department
Water Master Plan

COMPARISON OF ZONE REVENUE AND COSTS OF PROJECT FINANCING

(a) UPGRADED SYSTEM WITH ALTERNATIVES 1, 2B, 5A, 5B, 6, 7A, AND 8A
($1000)

Zone	Projected Annual Aver. Increase in Connections	Average Annual Zone Revenue 1/	Average Annual Share of Total Costs
1	91	$215	$65
2	46	$110	$28
3	91	$215	$54
4	238	$565	$198
5	7	$17	$4
6	0	$0	$56
7	0	$0	$0
TOTAL	473	$1,123	$405

(b) UPGRADED SYSTEM WITH ALTERNATIVES 1, 2B, 5A, 5B, AND 11 (North Coast Reservoir)
($1000)

Zone	Projected Annual Aver. Increase in Connections	Average Annual Zone Revenue 1/	Average Annual Share of Total Costs
1	91	$215	$214
2	46	$110	$104
3	91	$215	$204
4	238	$565	$591
5	7	$17	$16
6	0	$0	$56
7	0	$0	$0
TOTAL	473	$1,123	$1,185

1/ Based on $2375 per new connection.

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cost were allocated through other water rate components, the current connection charges could be maintained. A determination of the percentage of the capital cost to be allocated to future development is a relatively subjective matter. The value of increased reliability and water quality is difficult to quantify.

10.5 RECOMMENDATIONS

10.5.1 Connection Fees

The procedure described in Section 10.4.3 was used to determine whether current connection charges are adequate and if any special surcharges should be applied to particular zones for projects which provide disproportionate benefits.

As a result of the analysis conducted during this study, it is recommended that the SCWD retain its current schedule of connection fees for the following reasons:

(1) In general, the current charges appear adequate to provide sufficient revenue from future connections to construct additional water supply facilities required to serve the anticipated growth.

(2) Because the estimated benefit from the improvements is roughly proportional to the number of new connections, the revenue for financing new facilities will primarily come from future development which receives the associated benefit. Therefore, no special zone charges or surcharges appear necessary at this time.

(3) Although a complex set of fees which vary by zone or by customer classification may be slightly more equitable, the difficulties and costs associated with implementing and administering such a program are considerable.

However, if a costly new dam and reservoir is constructed, the connection charges should be increased slightly or part of the capital construction cost should be allocated through existing customers. Once the City Council determines which water supply alternatives should be pursued and detailed feasibility studies are conducted to provide firm cost estimates, the adequacy of connection charges should be reviewed and closely monitored in relation to future growth rates. For comparison, connection charges for other nearby water agencies are listed in Table 10-3.

Consideration should be given to providing discounts on connection fees when water conserving appliances, devices, and/or landscaping are used in new construction (other than those required by law). Such conservation measures will reduce the required need and cost for developing new sources of supply.

Table 10-3

City of Santa Cruz Water Department
Water Master Plan

COMPARISON OF CONNECTION CHARGES
FOR OTHER WATER AGENCIES

Water Agency	Participation Fee For Indicated Meter Size				
	5/8"	1"	2"	4"	8"
City of Watsonville	$1,025	$2,562	$8,199	$25,621	$117,855
City of Hayward	$1,630	$2,030	---	---	---
City of Santa Rosa	$1,710	$4,380	$17,510	$70,040	---
Contra Costa WD	$1,800	$3,800	$11,360	$34,600	$108,000
City of Santa Cruz	$2,735	$6,838	$21,880	$68,375	$314,525
Scotts Valley WD	$3,000	$7,500	$24,000	$75,000	---

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10.5.2 Water Main Extension Charges

From review of the City Council's Resolution No. NS-18,115 which established the current water rate schedule for the SCWD, a potential flaw in the wording of Section I.1 (Water Main Extension Charges) was discovered. The resolution stipulates that if an extension main is oversized for the purpose of general system improvement and is not dictated by the requirements of service to a particular development, the CITY will make a contribution to the developer based on the extension main size and length. This contribution only holds where the pipe installed is other than 4 or 6 inches in diameter.

Under the current wording, if a 12-inch main is installed where only a 6-inch main is required, the CITY will contribute $9.49 per foot of main. However, as the current schedule reads, if a 12-inch main is installed where only a 10-inch main is required, the contribution by the CITY is still $9.49 per foot of main. The CITY contribution should be less for the case where a 12-inch main is installed where only a 10-inch is needed than for the case where only a 6-inch is needed since the incremental cost difference is much less. Therefore, Section I.1 should be revised and expanded to reflect the true incremental differences in cost between the required main size and the installed main size.

APPENDIX A

LIST OF REFERENCES

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APPENDIX B

GLOSSARY OF TECHNICAL TERMS

acre-foot: volume of water which covers one acre to a depth of one foot--an acre is ten percent less area than a football field.

active storage: storage in a reservoir that is available for water supply and downstream use.

adjudication: court determination of water right for a stream or groundwater basin.

aquifer: geologic unit that will yield significant quantities of water to wells or springs--typically composed of sand, gravel, sandstone, limestone or fractured crystalline rock.

artesian: see confined aquifer.

confined aquifer: aquifer bounded above and below by relatively impermeable confining layers--also: artesian aquifer.

conjunctive use: coordinated use of groundwater resources with surface water resources.

consumptive use: portion of the water budget lost to evaporation and plant transpiration.

correlation: statistical relationship of one or more independent series with one dependent series.

dead storage: storage below the lowest outlet level of a reservoir and, hence, not available for use.

demand (water): schedule of the water requirements for a particular purpose, i.e., for municipal supply.

drainage area: area of a drainage basin or catchment for a particular stream or river system.

drawdown: the decline in groundwater level due to pumping from an aquifer.

evaporation, lake: quantity of water evaporated from a large open body of water, reservoir, or lake surface--usually expressed in inches of depth.

evaporation, pan: quantity of water evaporated from an evaporation pan of standard dimensions.

evapotranspiration: combination of evaporation from surface water, soil surfaces, and transpiration from plants.

firm yield: maximum amount of water that can be withdrawn every year from a water supply source.

groundwater: subsurface water in the zone of saturation.

groundwater basin: area underlain by permeable materials--the permeable materials must be water-bearing, i.e., capable of furnishing a water supply of acceptable quality to wells under moderately heavy pumping rates (100 gpm or more).

groundwater basin management: the planned use of a groundwater basin as to yield, storage space, transmission capability, and groundwater storage--it includes: (1) protection of natural recharge and use of artificial recharge; (2) planned variations in amount and location of pumping over time; (3) use of groundwater storage conjunctively with surface water; and (4) protection and planned maintenance of groundwater quality.

groundwater storage: the quantity of water in the zone of saturation.

historic flow: measured streamflow at a given location.

migration: movement from one area or habitat to another area--eg., fish migration from the ocean to a stream spawning area.

natural flow: flow that would have occurred under natural conditions--i.e., with no upstream reservoir storage or diversions.

operation study: evaluation of the performance of a reservoir under a continuous series of inflows, evaporation losses, and releases.

overdraft: condition produced by pumping a groundwater basin in excess of the basin's annual rate of recharge resulting in a decrease in storage and groundwater levels.

perennial yield: amount of water that can be withdrawn annually from the hydrologic system for an indefinite period without causing continued depletion of storage or a deterioration of the water quality of water.

potable water: fully treated water which can be used directly for human consumption.

reasonable use: legal doctrine which limits water rights to the quantity reasonably required for the beneficial use to be served.

recharge: addition of water to an aquifer--occurs naturally from infiltration of precipitation or runoff or may be artificially induced using basins, pits, or injection wells.

regression: statistical relationship between one dependent variable and one or more independent variables.

safe yield: see firm yield.

sea-water intrusion: encroachment of sea-water into a coastal aquifer due to pumping of groundwater that reverses the normal seaward flow of fresh water.

supply deficiency: a shortage of water supplies for a given year; the extent of the deficiency is the difference between the normal annual demand and the total available supply.

total storage: sum of the active storage and dead storage in a surface reservoir.

water table: upper surface of the zone of saturation--also: phreatic surface.

water year: 12-month period ending on September 30 of given year.

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APPENDIX C

UNIT CONVERSION TABLE

TO CONVERT	INTO	MULTIPLY BY
acres	square feet	43,560
acres	square miles	0.001562
acre-feet	cubic feet	43,560
acre-feet	gallons	325,800
acre-feet per day	cubic feet per second	0.504
acre-feet per day	gallons per minute	226
acre-feet per day	million gallons per day	0.326
acre-feet per year	gallons per minute	0.62
acre-feet per year	million gallons per day	0.0008924
British thermal units (BTU)	kilowatt-hours	0.0002928
cubic feet	gallons	7.48
cubic feet	acre-feet	0.0000230
cubic feet per second	acre-feet per day	1.98
cubic feet per second	acre-feet per month	60.3
cubic feet per second	gallons per minute	448.831
cubic feet per second	million gallons per day	0.646
days	seconds	86,400
feet	miles	0.0001894
feet of water	pounds per square inch	0.4335
feet per second	miles per hour	0.6818
gallons	cubic feet	0.1337
gallons	acre-feet	0.00000307
gallons of water	pounds of water	8.3453
gallons per minute	acre-feet per day	0.00442
gallons per minute	cubic feet per second	0.00223
gallons per minute	million gallons per day	0.00144
gallons per minute	acre-feet per year	1.16136
horsepower	BTU per minute	42.44
horsepower	kilowatts	0.7457
kilowatts	horsepower	1.341
miles	feet	5,280
million gallons	acre-feet	3.07
million gallons per day	acre-feet per day	3.07
million gallons per day	cubic feet per second	1.55
million gallons per day	gallons per minute	694
pounds per square inch	feet of water	2.307
tons	pounds	2,000

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